Shaw®

a world of Solutions™

Feasibility Study

Indian River Generating Station
Operable Unit No. 2
Burton Island Historical Ash Disposal Area
Millsboro, Delaware

Site Number DE-1399

Prepared for:

Indian River Power LLC
29416 Power Plant Road
Dagsboro, DE 19939

Prepared by:

Shaw Environmental, Inc.
150 Royall Street
Canton, MA 02021

Shaw Project No. 1009684036

November 2012

This page intentionally left blank.

Table of Contents

Tables

Figures

Table of Contents (continued)

Figures (continued)

Appendices

List of Acronyms

AUF	Area Use Factor
BMPs	best management practices
BSV	background screening value
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COCs	Constituents of Concern
COIs	Constituents of Interest
COPCs	Constituents of Potential Concern
COPECs	Constituents of Potential Ecological Concern
CSM	Conceptual Site Model
CWA	Clean Water Act
DNREC	Delaware Department of Natural Resources and Environmental Control
EHQ	Ecological Hazard Quotient
EPC	exposure point concentration
ESA	Endangered Species Act
ESV	ecological screening value
FE	Facility Evaluation
FIFRA	Federal Insecticides, Fungicide, and Rodenticide Act
ft	foot/feet
FS	Feasibility Study
HHRA	human health risk assessment
HI	hazard index
HMTA	Hazardous Materials Transportation Act
HQ	hazard quotient
HSCA	Hazardous Substances Cleanup Act
LOAEL	lowest-observed-adverse-effect-level
MW	megawatt
NAAQS	National Ambient Air Quality Standards
NOAEL	no-observed-adverse-effect-level
NPDES	National Pollutant Discharge Elimination System
NRG	NRG Energy, Inc.
O&M	operation and maintenance
OSHA	Occupational Safety and Health Administration
OU	Operable Unit
PCBs	polychlorinated biphenyls
RAOs	Remedial Action Objectives

List of Acronyms (continued)

RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
Shaw	Shaw Environmental, Inc.
SIPs	State Implementation Plans
SIRS	Site Investigation and Restoration Section
SLERA	Screening Level Ecological Risk Assessment
TAL	Target Analyte List
TRV	toxicity reference value
TSCA	Toxic Substances Control Act
TSP	total suspended particulate matter
UEC	Uniform Environmental Covenant
UECA	Uniform Environmental Covenants Act
URS	Uniform Risk-Based Remediation Standards
USC	U.S. Code
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
VCP	Voluntary Cleanup Program

Executive Summary

Shaw Environmental, Inc. (Shaw) prepared this Feasibility Study (FS) on behalf of Indian River Power LLC, for Operable Unit No. 2 (OU2) at the Burton Island Historical Ash Disposal Area (hereinafter referred to as 'the Site') located east of the Indian River Generating Station. This FS follows the Facility Evaluation (FE) and Remedial Investigation (RI) and was performed in conjunction with the Scope of Work outlined in the Voluntary Cleanup Program (VCP) Agreement DE-1399 between the Delaware Department of Natural Resources and Environmental Control (DNREC) and Indian River Power LLC, a wholly owned subsidiary of NRG Energy, Inc. (NRG). The FE was completed in 2008 and the RI was completed in 2011.

The areas of investigation for the Site are addressed as three Operable Units (OUs). The OUs are designated in the VCP Agreement generally as OU1 – shoreline, OU2 – former disposal areas inside shoreline, and OU3 – offshore. DNREC-Site Investigation and Restoration Section (SIRS) issued the *Final Plan of Remedial Action, Burton Island Old Ash Landfill Site, Operable Units 1 and 3* on August 5, 2008 (DNREC, 2008) based on the findings of the FE. The purpose of this report is to identify appropriate remedial technologies for OU2 at the Site which will achieve the remedial objectives based on the results of the RI, group these technologies into remedial alternatives that would address the contamination, and evaluate the alternatives to determine the most effective alternative for OU2.

The Remedial Action Objectives (RAOs) describe the expected condition and contaminant levels at the Site following remediation. The qualitative and quantitative RAOs for OU2 developed in coordination with DNREC-SIRS are as follows:

<u>Qualitative</u>

1. Minimize human cancer risks and non-cancer hazards from exposure to soil.
2. Minimize migration of constituents of concern (COCs) from OU2 to other OUs or off-site, including:
    a. Air to surface water or sediment.
    b. Runoff/erosion to surface water or sediment.
3. Reduce ecological risk (to terrestrial populations and communities) to lowest practicable levels.
4. Minimize unnecessary injuries to natural resources resulting from remedial action.
5. Ensure no significant degradation of groundwater, surface water, or sediment quality beyond existing levels.

<u>Quantitative</u>

1. Ensure human cancer risk is less than 1×10^{-5}.
2. Ensure human non-cancer Hazard Index (HI) is less than 1.

General response actions are generic types of remedial actions specific to media (i.e., soil, sediment, surface water, etc.) that can, alone or in combination, achieve the established RAOs for the site. The general response actions identified for soil at OU2 that alone or in conjunction with other response actions could potentially achieve RAOs include no action, land use controls, containment, removal, and treatment. General response actions are limited to those for soil because, based on the findings of the RI, there is no immediate risk driver to address the ponds at OU2 (i.e., sediment and surface water) or groundwater. Implementing measures to control any ongoing sources, such as the ash material in soil, and evaluating the effectiveness of those controls is the first step for any remediation at OU2.

For each general response action, one or more technology types and associated process options were identified that could potentially contribute to achieving RAOs. The technology types and process options were first screened based on technical practicability. Process options were eliminated during this screening step if they were not applicable for the fine-grained fly ash content of OU2 soil, not applicable for OU2 COCs (i.e., arsenic, barium, mercury, selenium, and thallium), or not applicable for subsurface conditions at OU2 (i.e., homogenous, shallow water table, and surrounding saline waters). The technology types and process options that were identified as practicable for soil at OU2 include no action; land use controls in the form of land use restrictions, signage, surveillance/perimeter patrols, and fencing; containment with cap or cover; removal via excavation; *in situ* and *ex situ* chemical treatment by solidification/stabilization; *in situ* biological treatment by phytoremediation; and *ex situ* chemical treatment by chemical extraction.

The retained technology types and process options were screened in a second step based on likely effectiveness, overall implementability, and relative cost. The technology types and process options that were retained for further evaluation in a remedial alternative include no action, land use controls, soil cover, and removal. The retained process options are combined into remedial alternatives to address soil at OU2. The identified remedial alternatives and the general components are as follows:

- **Alternative S-1: No Action**

  The No Action alternative does not include any active remediation, treatment, containment, removal, land use controls, or monitoring. The existing conditions would not be altered except perhaps by ongoing natural processes.

- **Alternative S-2: Targeted Soil Cover with Land Use Controls**

  The Targeted Soil Cover with Land Use Controls alternative includes clearing discrete areas of vegetation, grading and placing soil cover over discrete areas of currently exposed ash material in soil and unstable slopes in OU2, performing perimeter patrols, maintaining 'no trespassing private property' signs, establishing a Uniform Environmental Covenant (UEC) to limit future land use, and long-term monitoring.

- **Alternative S-3: Full Soil Cover with Institutional Controls**

  The Full Soil Cover with Institutional Controls alternative includes clearing vegetation from the entire surface of OU2, grading and placing soil over the entire surface of OU2, maintaining 'no trespassing private property' signs, establishing a UEC to limit future land use, and long-term monitoring.

- **Alternative S-4: Excavation and Off-site Disposal**

  The Excavation and Off-Site Disposal option includes clearing vegetation from the entire surface of OU2, excavating ash material at OU2, temporarily storing stockpiles on-site for waste characterization, transport and disposal of excavated material at a permitted facility, and stabilizing the excavated area.

The objective of the detailed analysis of remedial alternatives is to present the relative advantages and disadvantages of different contaminant management approaches for OU2. This is accomplished by evaluating the alternatives against the criteria that DNREC will use to make the selection of the preferred alternative. The evaluation of alternatives is a two-step process. First, the alternatives are individually evaluated against the criteria. Second, the alternatives are compared for each criterion. Alternatives must satisfy the first two criteria (i.e., initial threshold criteria) to be considered for the preferred alternative. A summary of the results of the comparative analysis is provided in **Table ES-1**.

Table ES-1

Summary of Comparative Analysis of Alternatives

ALTERNATIVE / CRITERIA	**S-1 No Action**	**S-2 Targeted Soil Cover with Land Use Controls**	**S-3 Full Soil Cover with Institutional Controls**	**S-4 Excavation and Off-site Disposal**
Threshold Criteria				
Protective of Public Health, Welfare, and the Environment	No	Yes	Yes	Yes
Complies with Applicable Laws and Regulations	No	Yes, easy	Yes, moderate	Yes, difficult
Balancing Criteria				
Community Acceptance	TBD	TBD	TBD	TBD
Compliance Monitoring Requirements	None	Moderate, short- and long-term	Moderate, short- and long-term	Easy, short-term
Technical Practicability	Easy	Easy	Moderate	Difficult
Restoration Time Frame (time to achieve RAOs)	NA	<1 year	3 years	23 years
Reduction of Toxicity, Mobility, and Volume of Contamination	None	Low reduction	Low reduction	High reduction
Long-term Effectiveness	None	Moderate	Moderate	High
Short-term Effectiveness	None	High	Moderate	Low
Cost	None	Low	Moderate	High

Notes:
NA – not applicable
TBD – to be determined

Based on the screening and detailed analysis presented in this FS, Alternative S-2, Targeted Soil Cover with Land Use Controls is the preferred remedial alternative for OU2. The Targeted Soil Cover with Land Use Controls alternative includes clearing discrete areas of vegetation, grading and placing soil cover over discrete areas of currently exposed ash material in soil and unstable slopes in OU2, performing perimeter patrols, maintaining ‘no trespassing private property’ signs, establishing a UEC to limit future land use, and long-term monitoring.

The Targeted Soil Cover with Land Use Controls alternative would limit potential exposure of humans and ecological receptors to ash material in soil at OU2 thereby minimizing potential risk, minimizing potential migration of COCs from OU2, and limiting unnecessary adverse impacts to natural resources. This alternative achieves the RAOs without incurring significant habitat and vegetation destruction for implementation. Potential future additional remedial actions can be readily implemented if deemed necessary by the results of long-term monitoring, which is a component of the preferred remedy.

1.0 Introduction

Shaw Environmental, Inc. (Shaw) prepared this Feasibility Study (FS) on behalf of Indian River Power LLC, for Operable Unit No. 2 (OU2) at the Burton Island Historical Ash Disposal Area (hereinafter referred to as ‘the Site’) located east of the Indian River Generating Station. This FS is the third work scope that was implemented in conjunction with the Scope of Work outlined in the Voluntary Cleanup Program (VCP) Agreement DE-1399 between the Delaware Department of Natural Resources and Environmental Control (DNREC) and Indian River Power LLC, a wholly owned subsidiary of NRG Energy, Inc. (NRG).

1.1 Purpose and Organization of Report

The purpose of this report is to identify appropriate remedial technologies for OU2 at the Site which will achieve the remedial objectives based on the results of the Remedial Investigation (RI), group these technologies into remedial alternatives that would address the contamination, and evaluate the alternatives to determine the most effective alternative.

This FS is comprised of six sections. Section 1 provides a discussion of the Site background information previously reported and most recently characterized in the RI, the remedial action objectives (RAOs), and the estimated volume of contaminated media. The development of remedial action alternatives is detailed in Section 2 in a multi-step identification and screening process. The detailed analysis of alternatives, including both individual and comparative analyses against the established evaluation criteria, are provided in Sections 3 and 4, respectively. The resulting preferred alternative is presented in Section 5. Referenced documents are identified in Section 6 at the end of this report.

1.2 Background Information

This section includes a brief history of the Site; a description of the physical characteristics of the Site; the nature and extent of contamination at OU2; contaminant fate and transport; baseline human health and screening-level ecological risk assessment findings; and a discussion of the applicable local, state, and federal requirements for remediation.

1.2.1 Site History

Delmarva Power & Light purchased Burton Island (the Island) in 1949 for the construction of the Indian River Generating Station. The facility consists of four coal-fired generating units with total capacity of 771 megawatts (MW). Units 1 and 2 are each 91 MW units and were placed in operation in 1957 and 1959, respectively. Unit 3 is 165 MW and was placed into service in 1970. Unit 4 is 424 MW and was placed into operation in 1980. Unit 2 was retired in 2010 and Unit 1 was retired in 2011.

Delmarva Power & Light began using the eastern end of the Island for ash disposal when Unit 1 was placed in operation in 1957. Fly ash and bottom ash were sluiced to the portion of the Island just beyond the operating power plant. Bottom ash was later removed and used to build roadways on the Island. Fly ash was used to construct a perimeter berm system. Berms were constructed at a height of approximately 20 feet, consisting of approximately a 4-foot base of native soil, 14 feet of fly ash, and a 2-foot cap of bottom ash. By the mid 1960's the system of berms and access roadways was completed on the eastern end of the Island. Fly ash was sluiced to the Island through a 12-inch pipe. The pipe was moved between the north side of the center access road and the south side approximately every two years to distribute the fly ash to the various cells. Water decanted from the fly ash flowed into a settling pond near the tip of the Island. Fly ash generated during power generation activities was deposited in this manner on the Island for a time period from approximately 1957 to 1979. With the start-up of Unit 4 in 1980, a new ash landfill was constructed and permitted to the south and across Island Creek from the Island. During the permitting of Unit 4 and the current ash landfill, the State of Delaware issued a letter defining requirements for the facility's operation of the Island which were considered as operational standards. Since the time the current ash landfill became operational in 1980, ash generated at the facility for the four units has been deposited in the current permitted ash landfill. The Indian River Generating Station was sold by Delmarva Power & Light to NRG in June 2001. Since the time of purchase, NRG has not used the Island for operational purposes.

The Operable Units (OUs) are designated in the VCP Agreement as follows:

- **OU1**: the shoreline areas of the Site including any areas that would be encompassed within the area of the erosion control project.
- **OU2**: the area of the Site inside (landward) of OU1 including the disposal areas.
- **OU3**: any subaqueous lands, wetlands, waters, or lands outside (riverward) of OU1 to which wastes or contaminants may have been conveyed (but excluding the currently operating permitted landfill and any legal off-site disposal).

A Facility Evaluation (FE) was conducted in 2007 and finalized in March 2008 (Shaw, 2008). The FE discusses the nature and extent of the constituents of interest (COIs) at the Site, as well as their fate and transport. The report also contains both a Human Health Risk Assessment (HHRA) and a Screening Level Ecological Risk Assessment (SLERA). DNREC-Site Investigation and Restoration Section (SIRS) issued the *Final Plan of Remedial Action, Burton Island Old Ash Landfill Site, Operable Units 1 and 3* on August 5, 2008 (DNREC, 2008) based on the findings of the FE. This "Final Remedial Action Plan Approval" summarized DNREC's concurrence with the results of the FE that no additional investigation was required for OU1 and OU3 at the Site and that no additional remediation was required for OU1 and OU3 after the shoreline stabilization project was complete. The "Final Remedial Action Plan Approval" stipulated that additional investigation was warranted for OU2.

The RI of OU2 further characterized the environmental media (e.g. surface and subsurface soil, groundwater, pond surface water, and pond sediment), and the potential human health and ecological risks at OU2. The RI for OU2 was a revision of and supplement to the data and analysis presented in the FE for OU2. Field work for the RI was performed in 2009 and 2010. The RI Report was finalized in August 2011 (Shaw, 2011).

1.2.2 Physical Site Description

The Indian River Generating Station (the 'facility') is located on Burton Island, which is actually a peninsula, between the Indian River to the north and Island Creek to the south. The facility is located approximately four miles downstream and east of the Millsboro Dam at Millsboro, Delaware and approximately nine miles west of the mouth of the Indian River to the Atlantic Ocean. The Site is bordered by the Indian River to the north and east, Island Creek to the south, and the Indian River Generating Station to the west. The Site location is depicted in **Figure 1-1**. The facility plan is identified on an aerial photograph background in **Figure 1-2** and the general Site topography is depicted on the site map in **Figure 1-3**.

The Indian River flows to the east forming the Indian River Bay. Indian River Bay is a shallow drowned river valley system with freshwater inflow and a direct connection to the ocean through the Indian River Inlet, located within Delaware Seashore State Park. Both the Indian River and Island Creek are tidally influenced. However, much of the flow in Island Creek comes directly from the cooling water discharge of the generating station.

According to the Sussex County Tax Assessor's Map, the tax parcel 233-2.00-2 which includes the Site, the active Indian River Generating Station, rail access, and undeveloped land west of the main facility is 539.53 acres. Based on land surveys, the area of the Site is approximately 111.5 acres with OU2 occupying approximately 93.6 acres of that footprint.

1.2.2.1 Vegetation Cover Type

As detailed in the OU2 RI, there were seven types of vegetative/habitat communities identified in OU2 during the October 2009 field survey. The compiled list of observed vegetation is included in the RI (Shaw, 2011). The invasive vegetative species common reed (*Phragmites australis*) was observed in each of the seven vegetative/habitat communities. The identified areas are depicted on **Figure 1-4**. The observed habitat communities were compared to those categorized in the "Guide to Delaware Vegetation Communities, Spring 2009" report prepared by Delaware Natural Heritage. The vegetative/habitat communities identified (and their corresponding Delaware Natural Heritage category in parentheses, if any) are as follows:

1. Blackberry dominated 20 to 90%, upland, dense herbaceous coverage at 75 to 90% ("*Northeastern Successional Shrubland*").
2. Black cherry dominated 25 to 70%, upland, herbaceous coverage at 45 to 90% ("*Successional Maritime Forest*").
3. Black locust mix dominated 5 to 70%, upland ("*Black Locust Forest*").

4. Bayberry/red maple dominated 25 to 100%, wetland/transition, herbaceous coverage at 0 to 15% ("*Wax Myrtle Shrub Swamp*").
5. Loblolly/common reed mix dominated 25 to 100%, upland.
6. Bayberry/loblolly dominated 50 to 100%, upland, little herbaceous coverage at 0 to 15% due to dense canopy ("*Loblolly Pine/Wax Myrtle*").
7. Common reed dominated >25%, upland, densely vegetated.

The field survey also included recording observations of areas of exposed ash in soil where vegetation was not established. In general, there was little to no exposed ash observed. Two primary areas of exposed ash in soil were identified and are associated with previous monitoring well installation and construction support areas; the other areas were relatively small, narrow, access road related and/or thinly covered with leaf litter. The areas of observed exposed ash in soil measured approximately 1 acre in total of the 93.6 acres of OU2. The percent cover of OU2 for each of the vegetated and other cover types are shown in **Table 1-1**.

Table 1-1

Percent Cover of OU2 by Vegetative and Habitat Community

Cover Type	Area (square feet)	Area (acres)	Percent Cover
Blackberry Dominated	167,659	3.8	4.1%
Black Cherry Dominated	148,791	3.4	3.6%
Black Locust Mix Dominated	855,616	19.6	21.0%
Bayberry/Loblolly Dominated	568,077	13.0	13.9%
Loblolly/Common Reed Mix Dominated	577,226	13.3	14.2%
Common Reed Dominated	1,186,034	27.2	29.1%
Bayberry/Red Maple Dominated	461,018	10.6	11.3%
Exposed Ash	45,834	1.1	1.1%
Ponds	12,570	0.3	0.3%
Access Roads	54,391	1.2	1.3%

1.2.2.2 Wildlife

Wildlife observed at the Site during the October 2009 vegetation/habitat field survey included a diverse population of 53 bird species as reported in the RI (Shaw, 2011). Select mammals (deer, fox, racoon, skunk, and mouse) and one amphibian (green treefrog) were also observed (Shaw, 2011). Additional wildlife species were observed during the July 2010 assessment of the ponds on the eastern tip of OU2 including green heron, blue-claw crab, fiddler crab, and minnows. Based on these observations, a variety of wildlife species are actively utilizing the Site and it appears to be a functioning ecosystem.

1.2.2.3 Wetlands

The wetland resources identified at the Site are limited to the shoreline outside the perimeter ash berms (i.e., primarily OU1 and waterward), the ponds on the eastern tip of the peninsula in OU2 (described in the following section), and the bayberry/red maple dominated wetland/transition area on the south-central portion of OU2.

Marginal wetland vegetation species (i.e., facultative) were observed throughout the wetland/transition area in the south-central portion of OU2; however, hydrology and soils characteristic of a wetland were only observed in the lowest-lying portions of the wetland/transition area where evidence of intermittent storm-related standing water was also observed. Based on the vegetation and habitat notes collected during the October 2009 field survey, the wetland portions of the wetland/transition area would likely be classified with definitions provided by the U.S. Fish and Wildlife Service (USFWS) as a combination of PSS1 (palustrine, scrub-shrub, broad-leaved deciduous) and PFO1 (palustrine, forested, broad-leaved deciduous). Palustrine is a freshwater wetland. The wetland portions of the wetland/transition area were not delineated during the October 2009 field survey; however, the wetlands would be subject to the jurisdiction of the U.S. Army Corps of Engineers.

The shoreline wetland delineation closely follows the boundary between OU1 and OU2 as determined during a 2005 shoreline study. In accordance with definitions provided by the USFWS, the shoreline wetlands of the study area were classed within the Estuarine system and the Intertidal subsystem, in which the substrate is exposed and flooded by tides, including any associated splash zone. Estuarine is a tidal wetland. Specifically, the study area wetlands were classified as Estuarine Intertidal Emergent (E2EM), Estuarine Intertidal Scrub/Shrub (E2SS), and Estuarine Intertidal Forested (E2FO). Based on the vegetation and habitat notes collected during 2010 field efforts conducted for the OU2 RI, the ponds and the immediate area of the ponds would likely be classified as E1US4M or E1US3M (estuarine, subtidal, unconsolidated shore, organic or mud, and irregularly exposed).

The field assessment of wetlands at the Site was performed in accordance with the U.S. Army Corps of Engineers manual for wetland delineation which is the standard; however, DNREC-Wetlands and Subaqueous Lands Section maintains jurisdictional maps of State-regulated wetlands in Delaware. These maps were generated from aerial imagery. The area of the Site is included on State Wetlands Maps DNR-116, -436, and -104. Wetlands in the immediate vicinity of the Site are identified on the State Wetlands Maps as either ‘M’ for “marsh” or ‘T’ for “tidal mudflats (in some cases vegetated)/sandbars” and are limited to the perimeter and shoreline of the site (i.e., primarily OU1 and OU3). The interior of the Site (i.e., primarily OU2) is identified as ‘O’ for “other (upland or non-tidal wetlands less than 400 acres)” on the State Wetlands Maps. The ponds on the eastern tip of OU2 and the bayberry/red maple dominated wetland/transition area are included in the ‘O’ designated area.

1.2.2.4 Ponds

Three ponds are present on the eastern tip of OU2 and are designated by relative location as Pond SW (southwest), Pond SE (southeast) and Pond NE (northeast).

Pond SW – Pond SW is located within a bermed area and measures approximately 160 feet in length and approximately 50 feet wide. The berms are continuous on three sides and contain the pond to the west, south, and east. The terrain slopes more gradually to upland on the north side of the pond. There is no visible direct surface water connection to Island Creek; however, hydraulic connection to Island Creek may occur during extreme tidal events. The *in situ* water quality parameters for Pond SW indicate brackish water. The dominant plant species surrounding the pond is *Phragmites australis* (common reed). The width of the Phragmites zone is approximately 30 feet on the north side of the pond and 5 feet on the south side. The mud in and adjacent to the pond was visually evaluated and appeared to be native material. However, cinders were noted in a depressed area directly north and west of Pond SW during the 2009 vegetation survey.

Pond SE – Pond SE is approximately 115 feet in length and 70 feet in width. Pond SE appeared to be a permanent water body, and communication with the tidal water of Island Creek is likely occurring at least during spring tides via a low area at the end of the berm at the east end of the pond. The pond is contained by berms to the south and west, and by more gradually sloping terrain to the north. There is no readily apparent communication between Pond SE and nearby Pond SW. Groundsel bush (*Baccharis halimifolia*), a facultative species common in higher portions of salt marshes, was present in the berm to the south of the pond and elsewhere in the vicinity. Other vegetation surrounding Pond SE included marsh elder, (*Iva frutescens*), common reed (*Phragmites australis*) and cord grasses. The band of Phragmites surrounding Pond SE is narrow on the Island Creek side and wider to the north. The sediment was a muddy sand which appeared to be native material. No ash or cinders were observed in the pond shoreline sediment.

Pond NE – Pond NE is long and narrow, approximately 150 feet long and 25 feet wide. A high berm parallels the western side of the pond and a low berm parallels the pond to the east. The topography to the south of the pond is flatter and gently sloping. Pond NE appears to be a permanent salt pond that communicates with the Indian River during spring tides via low terrain to the north. The bottom substrate of Pond NE was soft black mud which appeared to be native material. A small area (several square feet) of what appeared to be cinders or bottom ash was observed on the west bank of the pond. There is a narrow fringe of *Spartina alterniflora* around the pond, with the *Spartina* extending to the north towards the Indian River. Other vegetation observed adjacent to Pond NE included marsh elder and groundsel bush.

1.2.2.5 Groundwater

Columbia sand deposits (Pleistocene age) underlain by the sands of the Upper Miocene deposits are the uppermost conductive materials (aquifer) underlying the Site. The Columbia sand deposits range in thickness from less than 50 to over 125 feet in southern Delaware[1] and are comprised of predominantly medium-grained sand with varying mixtures of silt and gravel. The Miocene sediments generally consist of sand units interbedded with silty clay layers. The first aquitard underlying the aquifer is likely the silty clay in the Upper Miocene deposits that occurs 75 to 95 feet below the shoreline. During the FE, it was discovered that up to 8 feet of ash above the top of the Columbia sand was saturated in places. As such, this saturated portion of ash is part of the local aquifer as well.

The Conceptual Site Model (CSM) for groundwater was presented in the FE (Shaw, 2008). Although there had been no direct measure of the direction of groundwater flow beneath Burton Island prior to the FE, the narrow peninsula seemed to dictate that flow be radial outward from central portions of the peninsula towards the shoreline surrounding the peninsula. Reversals of flow gradient from outward to inward may occur at some frequency in response to high tide water levels in the surrounding water bodies (Indian River and Island Creek).

A groundwater investigation was conducted for the OU2 RI (Shaw, 2011) to supplement data collected during the FE (Shaw, 2008) and these data were used to assess the water bearing zones in the region around Burton Island and the connectivity between groundwater under OU2 and both the surface water and local drinking water aquifer. This resulted in a revised CSM. As part of the development of the revised CSM and based on the tidal study data, mounding of the water table in the interior of OU2 was determined to be present all of the time but only up to 3.32 feet higher than the water levels in the surrounding surface water bodies.

In situations where there is a water table aquifer underlying a land mass of limited extent, such as the Burton Island peninsula, terrestrial fresh water recharge is limited and the surrounding saline water envelope restricts the outward flow of fresh groundwater. This effect on fresh groundwater flow paths is illustrated in the depiction of the revised CSM on **Figure 1-5.** Due to this effect there would be no flow path and thus no pathway of exposure from groundwater affected by leachate on the Site to water supply wells inland of the north shoreline of Indian River, north of the Site or to water supply wells inland of the south shoreline of Island Creek, south of the Site.

Short duration discharges of less dense groundwater from the Site to the surrounding surface water bodies occur during those low tide conditions when the difference in elevation between groundwater and surrounding surface water are greatest. Dissolved metals can pass from the fresh water system (i.e. Burton Island groundwater) into the saline surface water bodies (i.e., Indian River and Island Creek)

---

[1] Johnston, R.H. 1973. Hydrology of the Columbia (Pleistocene) Deposits of Delaware: An Appraisal of a Regional Water Table Aquifer. Delaware Geological Survey, Bulletin No. 14.

during these times. However, there are likely some differences in the chemistries of the fresh groundwater affected by coal ash, the pore water in the sediments of the surrounding surface water bodies, and the saline surface waters themselves. These differences are likely to induce chemical reactions that would reduce the concentrations of certain metals passing from groundwater to surface water during the times of outward flow. With the revised CSM, there is an understanding of when and to what extent mass loading can occur. The potential mass loading would not be expected to have an adverse effect on surface water quality, as was demonstrated by surface water samples collected during the FE (Shaw, 2008) and further evaluated in the RI (Shaw, 2011).

1.2.3 Nature and Extent of Contamination

The nature and extent of COIs related to OU2 at the Site has been defined through investigations conducted for the FE (Shaw, 2008) and the RI (Shaw, 2011). OU2 consists of soil, pond sediment, pond surface water, and groundwater; therefore, discussion of nature and extent of contamination is limited to these media in OU2. The RI field activities at OU2 included the collection of soil, pond sediment, pond surface water, and groundwater samples to supplement data collected for the FE (Shaw, 2008).

Soil samples were collected from surface and subsurface depth intervals at 84 locations across the 93.6 acres of OU2 and composited into 14 samples for each depth interval. The soil sampled during the surface and subsurface field investigation were predominantly ash with sand cover. The ash was consistently very fine grained, gray, dry, and loose. No biological inclusions (e.g., shells, bones, etc.) were observed in any sample. Statistics were used to compare the surface (0-6") and subsurface (2'-3') data sets for Target Analyte List (TAL) metals. The objectives of the statistics were to determine 1) if the surface material is homogeneous throughout OU2, 2) if the subsurface material is homogeneous throughout OU2, and 3) if any significant differences exist between the surface material and subsurface material. It was concluded that metals concentrations are generally homogeneous between surface and subsurface materials and across the entirety of OU2. Similar to the results of the FE soil sampling (Shaw, 2008), the results of the RI soil sampling (Shaw, 2011) indicated that select TAL metals were the only preliminary COIs in soil at OU2 based on comparison to the soil Uniform Risk-Based Remediation Standards (URS) for the protection of human-health and the environment (DNREC, 1999).

One sediment and one surface water sample were collected from each of the three ponds located at the eastern end of OU2 during the RI (Shaw, 2011). TAL metals were the only preliminary COIs in pond surface water and pond sediment at OU2 based on comparison to the surface water and sediment URS for the protection of the environment and Delaware default background standards (DNREC, 1999). Statistical comparisons of the detected concentrations of TAL metals in pond surface water and sediment to shoreline surface water and sediment were completed in the RI (Shaw, 2011). An additional comparison of the detected concentrations of TAL metals in pond sediment to the off-shore sediment (OU3) was completed for this FS (**Appendix A**). Detected concentrations of TAL metals in surface water and sediment samples from the ponds were determined to be statistically similar to the concentrations detected in OU1 and OU3 surface water and sediment samples; therefore, the findings of the FE are also applicable to the ponds. Thus, the following conclusions of the FE with regard to surface water and sediment are applicable to the three ponds investigated as part of the OU2 RI.

For sediment:

- no ecological hazard from exposure to sediment through food web interactions;
- possible but not probable potential for adverse effects on benthic invertebrates due to arsenic and barium in sediment; and
- no further ecological evaluation is recommended for sediment.

For surface water:

- no ecological hazard from exposure to surface water through food web interactions;
- the likelihood of adverse effects from exposure to arsenic and barium in surface water is minimal; and
- no further ecological evaluation is recommended for surface water.

Groundwater samples were collected from 14 monitoring wells, including 5 newly installed wells. The preliminary COIs, based on a comparison to groundwater URS for the protection of human health and site-specific background (MW-9) values, are arsenic, barium, iron, and manganese. The tidal study results were used to refine the CSM and to determine that Burton Island groundwater does not communicate with potable water aquifers on the opposite shorelines; therefore, potential human exposure pathways for groundwater are incomplete.

1.2.4 Contaminant Fate and Transport

The environmental fate and transport of constituents in the various environmental media associated with OU2 at the Site will govern the potential for exposures to human and ecological receptors. In general, constituents in environmental media may be available for direct exposures (e.g., plants exposed to ash material in surface soil) and they may also become available for indirect exposures (e.g., accumulation of constituents in fish with subsequent consumption by recreational fishermen).

One potential transport mechanism for OU2-related constituents to enter the environment is through leaching from the ash material into local groundwater and the transport of this leachate with local groundwater flow. As discussed in the RI (Shaw, 2011) and summarized in Section 1.2.2.5 of this FS, the groundwater flow regime beneath the Site is a dynamic system that reverses flow direction depending on the tidal fluctuations of Indian River and Island Creek. Although the direction of flow of impacted groundwater beneath the Site fluctuates depending on the tidal cycle, there is no pathway to potable water aquifers. Groundwater at the Site does not connect to the local drinking water aquifer. As there is no groundwater pathway from OU2 to off-site receptors, this potential exposure pathway is considered incomplete and no quantitative human health risk assessment was performed to evaluate this incomplete pathway. In addition, as discussed in Section 1.2.2.5, the potential mass loading of dissolved metals from the Site groundwater to surface water would not be expected to have an adverse effect on sediment and surface water quality. As such, the condition of no significant risk from exposure to sediment and surface water, as described in the FE and supported with empirical data, is not anticipated to change.

Another potential physical transport mechanism for constituents in impacted media at OU2 is soil transport via overland flow. The overland flow pathway has been significantly minimized by the implementation of shoreline stabilization measures at OU1 (Shaw, 2011) and is, therefore, not considered significant for the revised risk assessment. As such, the condition of no significant risk from exposure to surface water and sediment as described in the FE and supported with empirical data, is not anticipated to change due to potential overland flow contribution. Additionally, the FE identified no significant risk from exposure to sediment and surface water when the shoreline was eroding (i.e., prior to the implementation of the shoreline stabilization project) and the overland flow model presented in Section 3.4 of the RI (Shaw, 2011) demonstrates that the contributions of soil, ash, and associated COIs from erosion are significantly reduced.

Another potential physical transport mechanism for constituents in impacted media at OU2 is surface soil transport and dispersion via fugitive dust. Although fugitive dust generation and transport via air dispersion is a potential transport mechanism for constituents in surface soil at OU2, this transport mechanism is considered insignificant. The results of the fugitive dust generation and dispersion analysis presented in Section 4.0 of the RI (Shaw, 2011) show that concentrations of particulate matter with aerodynamic diameter less than a nominal 10 micrometers (PM_{10}) and particulate matter with aerodynamic diameter less than a nominal 2.5 micrometers ($PM_{2.5}$) are expected to be less than their respective National Ambient Air Quality Standards (NAAQS) at the closest sensitive receptor locations assuming the Site remains vegetated at its current level. Based on this fugitive dust generation and dispersion analysis, the inhalation exposure pathway is considered to be negligible. No further risk assessment is required to evaluate this pathway.

If site-related constituents enter the surrounding water bodies, either by leaching to groundwater and subsequent discharge to surface water or erosion and runoff into the intertidal areas, they may be bioaccumulated by fish and/or shellfish that utilize the surrounding water bodies for feeding and breeding habitat. Fish, shellfish, or other organisms living in Indian River or Island Creek in the vicinity of the Site may bioaccumulate site-related constituents. This transport mechanism is addressed in the human health and screening level ecological risk assessments. Other potential transport mechanisms, such as uptake by terrestrial plants, bioaccumulation into terrestrial organisms, and trophic transfer via the food web are addressed in the human health and screening level ecological risk assessments.

In summary, the initial fate and transport mechanisms for site-related constituents in OU2 soil consist of leaching to groundwater, erosion and stormwater runoff, windblown dust, uptake by terrestrial plants, and bioaccumulation into terrestrial organisms. Once transported from OU2 soil, site-related constituents may be subsequently transported to other media or biological systems which were evaluated in the FE for OU1 and OU3. Leaching to groundwater is not evaluated in the human health risk assessment for OU2 because there is no complete exposure pathway to groundwater for off-site receptors. Leaching to groundwater with subsequent discharge to surface water and stormwater runoff were evaluated in the ecological risk assessment of OU1 and OU3 through the collection and analysis of numerous shoreline and offshore surface water and sediment samples, and the conclusions of the FE with regard to surface water and sediment were determined to be applicable to the three ponds in OU2. Stormwater runoff from OU2 is not evaluated in the human health risk assessment because the potential contribution via this transport mechanism is not significant due to the completion of the shoreline stabilization project. Windblown dust is not evaluated in the human health or ecological risk assessments for OU2 because fugitive dust generation from OU2 was determined to be negligible. Therefore, the only fate and transport mechanisms for site-related constituents in soil at OU2 which were evaluated in the human health and/or ecological risk assessments for OU2 include bioaccumulation by terrestrial plants, bioaccumulation into terrestrial organisms, and trophic transfer via the food web.

1.2.5 Baseline Risk Assessment

The human health and screening level ecological risk assessments presented in the FE (Shaw, 2008) for OU2 were revised in the RI (Shaw, 2011). This section briefly describes the processes and findings for the human health and ecological risk assessments as presented in detail in the RI (Shaw, 2011).

1.2.5.1 Human Health Risk Assessment

A human health risk assessment (HHRA) was conducted to determine the types and magnitudes of exposures to constituents originating from OU2 and to determine the potential carcinogenic risks and non-carcinogenic health hazards posed by the estimated exposures.

For this HHRA, constituents of potential concern (COPCs) were identified in surface soil as those constituents whose exposure point concentrations (EPCs) exceeded the URS for the protection of human health, based on restricted use in a critical water resource area and/or its associated background screening value (BSV). The only constituent that was identified as a COPC in surface soil at OU2 was arsenic.

The only potential human exposure to ash material from OU2 that could be considered somewhat routine would be recreational boaters/fishermen who utilize Indian River and Island Creek as a fishing ground. There are no on-site residents at OU2 to potentially be exposed and no complete exposure pathways for off-site residents. Plant personnel and construction workers on-site may experience only insignificant exposures mitigated by health and safety requirements. Therefore, the HHRA evaluated the recreational fishermen and their family's receptor population for potential exposures to COPCs via ingestion of fish/shellfish and incidental ingestion of soil and dermal absorption of soil while illegally trespassing on the Site. The human health CSM presented in **Figure 1-6** identifies constituent sources, migration routes, and potential exposure pathways for the trespassing recreational fisherman.

The carcinogenic risks were calculated for arsenic, the only COPC considered carcinogenic. The estimated carcinogenic risks are within the USEPA's recommended risk range and DNREC's limit for adult trespassing recreational fishermen. The estimated carcinogenic risks for child trespassing recreational fishermen are also within the USEPA's recommended risk range, but marginally exceed

DNREC's limit. The risks from fish/shellfish ingestion are associated with OU1, and the risks from ingestion of soil and dermal absorption of soil are associated with OU2. If illegal trespassing on the Site by child recreational fishermen was limited to fewer than 16 events per year, then all of the calculated risks associated with exposure to surface material at OU2 would be less than the risk levels specified by USEPA and DNREC. Because land access is secure, because of the dense vegetation along the shoreline and the fact that the recent revetment projects add a factor of difficulty for boat access to 95 percent of OU1 (the shoreline surrounding OU2), illegal trespassing is highly unlikely. The fact that illegal trespassing on the Site has rarely been observed leads to the expectation that such a significant level of illegal trespassing (16 or more events per year by the same individual) would not occur.

The estimated non-carcinogenic hazard quotients (HQs) are less than the USEPA's and DNREC's target hazard index (HI) of 1.0 for adult and child trespassing recreational fishermen, except for arsenic, which slightly exceeds the target HI of 1.0 for child trespassing recreational fishermen. The non-cancer hazards from fish/shellfish ingestion are associated with OU1, and the non-cancer hazards from ingestion of soil and dermal absorption of soil are associated with OU2. If illegal trespassing of child recreational fishermen is limited to fewer than 16 events per year, as indicated in the previous paragraph, then all of the calculated non-cancer hazards associated with exposure to surface material at OU2 would be less than the non-cancer hazard levels specified by USEPA and DNREC.

Although fish/shellfish ingestion was assessed in conjunction with OU1 and OU3 and it was determined that the "level of contamination present at Burton Island did not pose an undue health risk to an adult or child who may be exposed to the contaminants from eating fish from the local waters" (DNREC, 2008), this potential exposure pathway was incorporated into the assessment of OU2 in order to estimate total cumulative risks/hazards experienced by the trespassing recreational fisherman receptor population.

It should be noted that the DNREC Division of Water Resources currently prohibits the harvesting of shellfish from the waters surrounding the Site and other areas of the Delaware Inland Bays due to the potential for bacterial pollution not related to the Site or the Indian River Generating Station. This shellfish harvesting prohibition currently effectively eliminates legal human exposures to shellfish from these prohibited areas (including the area surrounding the Site). Additionally, there is a fish consumption advisory for Delaware Atlantic coastal waters including the Delaware Inland Bays recommending the consumption by adults of no more than one eight-ounce meal per year of bluefish greater than 14 inches for polychlorinated biphenyls (PCBs) and mercury and none for women of childbearing age or for children (DNREC, 2009).

It is also interesting to note that in a recent study conducted to measure arsenic concentrations in marine fish in the Delaware Inland Bays, Greene and Crecelius (2006) found that fish migrating into the Inland Bays in the spring had higher concentrations of arsenic in their tissues than fish migrating out of the Inland Bays in the fall after spending the summer within the Inland Bays. These results indicate that the

Inland Bays do not contribute significantly to the overall fish tissue burden of arsenic exhibited by migrating fish species.

Therefore, it can be concluded that site-related constituents in surface soil and sediment do not pose significant risks/hazards to the adult or child trespassing recreational fisherman receptor population except for arsenic, which has the potential for marginally increased carcinogenic risk and non-carcinogenic hazard for the child trespassing recreational fishermen assuming conservative exposure parameters. If more realistic exposure parameters are considered, all of the estimated carcinogenic risks and non-carcinogenic hazards for child trespassing recreational fishermen associated with exposure to surface material at OU2 are less than the risk/hazard levels specified by USEPA and DNREC. In addition, that risk would be further reduced/managed with existing and enforced land use controls (i.e., controlling access to OU2).

1.2.5.2 Screening Level Ecological Risk Assessment

A SLERA was conducted in order to assess the potential ecological hazards from exposures to surface soil at OU2. Measures of effects were divided into two general categories for this SLERA: community-level measures of effect and food web measures of effect. Ecological hazards for community-level receptors were estimated by calculating Ecological Hazard Quotients (EHQs) for each constituent of potential ecological concern (COPEC) in surface soil including arsenic, barium, mercury, nickel, selenium, and thallium. Ecological hazards for higher trophic level organisms that could potentially be exposed to surface soil from the Site through food web interactions were estimated by calculating EHQs for each COPEC in terrestrial ecosystems.

Soil Community Assessment

Soil communities assessed in the ecological risk assessment include terrestrial plants and terrestrial invertebrates. As such, the soil communities that were assessed in the SLERA encompass OU2. Plant communities and terrestrial invertebrate communities were assessed by comparing estimated soil exposure point concentrations to ecological screening values (ESVs) for the protection of terrestrial plants and terrestrial invertebrates.

The soil EPCs for arsenic, barium, mercury, selenium, and thallium exceed their respective terrestrial plant and terrestrial invertebrate ESVs and indicate the potential for ecological hazards to these soil communities. It should be noted that the plant and terrestrial invertebrate ESVs used in this assessment are based on laboratory studies using the most sensitive plant and invertebrate species available. As such, the ESVs may not represent the environmental conditions present at the Site, and may over-estimate the potential for ecological hazards to terrestrial plant and invertebrate communities.

Terrestrial Food Web Assessment

Terrestrial habitats at OU2 were assessed in the SLERA via a terrestrial food web model. The terrestrial food web model utilized surrogate receptor species to represent the different feeding guilds that utilize the upland portion of OU2 for feeding, nesting, and other normal activities.

The terrestrial food web model assessed OU2 utilizing measured surface soil concentrations and modeled food concentrations of COPECs to estimate total potential exposures for terrestrial feeding guilds. Based on the conservative lowest-observed-adverse-effect-levels (LOAELs), only arsenic and barium produce EHQs greater than one for the omnivorous bird feeding guild. Based on the no-observed-adverse-effect-levels (NOAELs), the highest concentrations at which no affect is observed (and a more conservative comparison than LOAELs), the EHQs were greater than one for the herbivorous mammal (barium only), omnivorous small mammal (barium and thallium only), omnivorous bird (arsenic, barium, and methyl-mercury), invertivorous small mammal (arsenic, barium, selenium, and thallium), and invertivorous bird (arsenic, barium, and methyl-mercury) feeding guilds. EHQs were less than 1 for the herbivorous bird, omnivorous large mammal, and carnivorous bird feeding guilds.

Although the terrestrial food web model showed that the calculated EHQs for several of the feeding guilds were greater than one, it is important to note that these food web models, by their conservative design and the current state of the science of ecological risk assessment, assess sensitive individuals within each feeding guild, and do not assess ecological populations or communities. USEPA (1997) guidance provides for the assessment of ecological communities and/or populations; however, the current state of the science of ecological risk assessment does not support population-level assessments. There is no generally accepted method to account for the difference between adverse impacts to individuals and adverse impacts at the population level. Therefore, the results of the food web model are highly conservative and these results should be viewed with that conservative bias in mind.

In order to demonstrate the effect of several of the conservative assumptions on the terrestrial food web model and resulting over-estimation of ecological risk for the Site as presented in the RI, the terrestrial food web model was revised with more realistic input parameters. Values were selected from within USEPA's acceptable ranges for well-studied parameters that better represent the Site as opposed to the default conservative values previously used in the RI. The revised food web assessment is presented in **Appendix B**. The results of the revised terrestrial food web model indicate that under current site conditions, ecological hazards at OU2 may already be at acceptable levels and remedial actions may not be necessary in order to ensure the protection of ecological receptors at OU2.

1.2.6 Applicable Local, State, and Federal Requirements

Hazardous Substances Cleanup Act (HSCA) regulations require that applicable requirements be used to guide development of remedial action objectives, to evaluate remedial alternatives, and to govern the implementation and operation of the selected remedy. Applicable requirements are defined as all local, state, and federal environmental laws and regulations such as cleanup levels, standards of control, and other environmental protection requirements, criteria, or limitations promulgated under federal or state law or local ordinance that specifically address a hazardous substance, cleanup action, location, or other circumstances at the facility.

The HSCA regulations also stipulate that applicable requirements may receive a regulatory variance if the substantive conditions of the requirement are met. In all such cases, remedial actions must still be protective of public health and the environment.

Applicable requirements for remedial action are generally classified into one of the following three functional groups:

- Chemical-specific (i.e., requirements that set protective exposure levels for the chemicals of concern);

- Location-specific (i.e., requirements that restrict remedial actions based on the characteristics of the site or its immediate environs); and

- Action-specific (i.e., requirements that set controls or restrictions on the design, implementation, and performance of activities related to the management of hazardous substances, pollutants, or contaminants).

1.2.6.1 Chemical Specific Applicable Requirements

Chemical-specific requirements set health or risk-based concentration limits or ranges in various media for specific hazardous substances. These requirements provide protective site exposure levels (as a basis for calculating cleanup levels) for the chemicals of concern in the designated media. Chemical-specific requirements are also used to indicate an acceptable level of discharge to determine treatment and disposal requirements that may occur in a remedial activity, and to assess the effectiveness of the remedial alternative. Potential chemical-specific applicable requirements for OU2 are summarized in **Table 1-2** at the end of Section 1.2.6.

1.2.6.2 Location Specific Applicable Requirements

Location-specific requirements set restrictions on the types of remedial activities that can be performed based on site-specific characteristics or location. Remedial action alternatives may be restricted or precluded based on federal and state siting laws for hazardous waste facilities, proximity to wetlands or flood plains, or presence of endangered species or cultural resources. Location-specific requirements must be addressed during the formulation and evaluation of potential location-specific remedies. Potential location-specific applicable requirements for OU2 are summarized in **Table 1-3** at the end of Section 1.2.6.

1.2.6.3 Action Specific Applicable Requirements

Action-specific requirements are triggered by the particular remedial alternatives that are selected to accomplish the cleanup. These action-specific requirements may include, for example, solid waste transportation and handling requirements, water discharge standards, and treatment requirements.

Potential action-specific applicable requirements for OU2 are summarized in **Table 1-4** at the end of Section 1.2.6.

1.2.6.4 Other Considered Requirements

Other laws or regulations that were considered in this evaluation but not considered to be applicable include: Resource Conservation and Recovery Act (RCRA) and associated federal and Delaware Hazardous Waste regulations; Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); Superfund Amendments and Reauthorization Act (SARA); Hazardous Materials Transportation Act (HMTA); Toxic Substances Control Act (TSCA); Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA); and Safe Drinking Water Act (SDWA). The Archaeological Resources Protection Act of 1979 (16 U.S.C. Section 470aa) which provides for the protection of archaeological resources and sites on public lands and Indian lands does not apply to OU2 because the subject property is not on public or Indian lands.

Table 1-2

Potential Chemical-Specific Applicable Local, State, and Federal Requirements for OU2

Requirement	**Citation**	**Content/Purpose**	**Applicability for OU2**
Delaware Hazardous Substance Cleanup Act and the Delaware Regulations and Remediation Standards Guidance Governing Hazardous Substance Cleanup	Title 7 Delaware Code Chapter 91	The HSCA regulations establish the administrative processes and standards to identify, investigate, and cleanup facilities with a release or imminent threat of release of hazardous substances.	Delaware critical water resource area restricted use standards for surface and subsurface soil and Delaware standards for surface water and sediment.
State of Delaware Surface Water Quality Standards	Title 7 Delaware Administrative Code Chapter 7401	These standards set forth water quality standards for surface waters of the state. The standards are based upon designated water uses that are to be protected, and the propagation and protection of fish and aquatic life, and are considered by DNREC in its regulation of discharges to surface waters.	These standards are applicable to point and non-point discharges from the site to surface water.

Table 1-3

Potential Location-Specific Applicable Local, State, and Federal Requirements for OU2

Requirement	Citation	Content/Purpose	Applicability for OU2
Wetlands Protection	(40 CFR Parts 22, 230-233	These regulations under the Clean Water Act require that activities in or affecting wetlands be conducted in a manner that avoids adverse effects, minimizes potential harm, and restores and preserves the beneficial values of these areas.	These regulations may be applicable if remediation or disturbance of the pond areas within OU2 is part of a proposed remedy.
Delaware Wetlands Regulations	Title 7 Delaware Code Chapter 7502	The purpose of these regulations is to preserve and protect wetlands of the State and the regulations require that a permit be obtained from the State for activities in wetlands.	These regulations may be applicable if remediation or disturbance of the pond areas within OU2 is part of a proposed remedy.
Delaware Regulations Governing the Use of Subaqueous Lands	Title 7 Delaware Code Chapter 7504	These regulations provide for the protection against uses or changes which may impair the public interest in the use of tidal or navigable waters. They regulate activities such as dredging, draining, filling, grading, excavation, and construction of any kind. Applicable to tidal (up to the mean high water line) and non-tidal (up to the ordinary high water line) waters.	These regulations may be applicable if remediation or disturbance of the pond areas within OU2 is part of a proposed remedy.

Table 1-3 (continued)

Potential Location-Specific Applicable Local, State, and Federal Requirements for OU2

Requirement	**Citation**	**Content/Purpose**	**Applicability for OU2**
Archaeological and Historical Preservation Act of 1974	16 U.S.C. Section 469-469c	This Act provides for the preservation of historical and archeological data (including relics and specimens) which might otherwise be irreparably lost or destroyed as the result of any alteration of the terrain caused as a result of any federally licensed activity or program.	The only portion of activities related to the OU2 remedies where this Act may be applicable is for the ponds where a permit from the U.S. Army Corps of Engineers could be required prior to disturbance. As such, an effort would be made to identify any potential resources that might be put at risk by the construction activities related to the OU2 remedies in the ponds. Because previous consultation with the State Historic Preservation Office for construction activities conducted in the vicinity of OU2 (i.e., OU1 shoreline stabilization) did not identify any affected historic properties, it is unlikely that this requirement would affect remedial action activities.
National Historic Preservation Act	16 U.S.C. Section 470	This Act establishes a national preservation program and a system of procedural protections which encourage the identification and protection of cultural and historic resources of national, state, tribal, and local significance. If historic properties are found on or near the site, action will be taken to mitigate any adverse effects on those properties resulting from the remedial activities.	Because previous consultation with the State Historic Preservation Office for construction activities conducted in the vicinity of OU2 (i.e., OU1 shoreline stabilization) did not identify any affected historic properties, it is unlikely that this requirement would affect remedial action activities.

Table 1-3 (continued)

Potential Location-Specific Applicable Local, State, and Federal Requirements for OU2

Requirement	Citation	Content/Purpose	Applicability for OU2
Coastal Zone Management Act of 1972	16 U.S.C. Section 1451	This Act and its Amendments provides for management of the nation's coastal resources and balances economic development with environmental conservation. The Act provides that each federal agency conducting or supporting activities affecting any land or water use or natural resource of the coastal zone, must do so in a manner which is, to the maximum extent practicable, consistent with the approved state coastal zone management program.	The Delaware Coastal Management Program defines its Coastal Management Area as the entire state. The only portion of activities related to the OU2 remedies where this Act may be applicable is for the ponds.
Delaware Coastal Zone Act	Title 7 Delaware Code Chapter 70	In accordance with similar federal legislation, the Act controls the location, extent, and type of industrial development in Delaware's coastal areas to better protect the natural environment of the bay and coastal areas. The implementing regulations govern the State permit system and review of federal action consistency with state policies. The following is listed under "Uses Not Regulated:" "installation and modification of pollution control and safety equipment for nonconforming uses within their designated footprint providing such installation and modification does not result in any negative environmental impact over and above impacts associated with the present use."	The Site is located in the Delaware Coastal Zone, also referred to as the Coastal Strip of Delaware. The activities contemplated under and associated with remedial action would be allowed under the "Uses Not Regulated" exemption.
Regulations Governing Delaware's Coastal Zone	Title 7 Delaware Administrative Code Section 101		
Delaware Coastal Management Program Federal Consistency Policies and Procedures	Title 7 Delaware Administrative Code Section 5104		

Table 1-3 (continued)

Potential Location-Specific Applicable Local, State, and Federal Requirements for OU2

Requirement	Citation	Content/Purpose	Applicability for OU2
Delaware Sea Level Rise Policy	DNREC Sea Level Rise Adaptation (Subject D-1306, Section D-1300) issued January 27, 2010	The policy states that sea level rise is currently occurring and will continue to occur at an accelerated rate due to global climate change. Further, it is the policy of DNREC to proactively consider and plan for the potential effects of coastal inundation department-wide using scenarios based on the best available science. As of February 1, 2010, the planning scenarios for Delaware are 0.5 meters for low sensitivity projects, 1.0 meters for medium sensitivity projects, and 1.5 meters for high sensitivity projects by the year 2100.	The potential effects of coastal inundation on the long-term effectiveness of remedial alternatives would be evaluated using the maximum rise of 1.5 meters specified by DNREC for the year 2100.

Notes:

CFR – Code of Federal Regulations

USC – U.S. Code

Table 1-4

Potential Action-Specific Applicable Local, State, and Federal Requirements for OU2

Requirement	Citation	Content/Purpose	Applicability for OU2
Delaware Uniform Environmental Covenants Act	Title 7 Delaware Code Chapter 79	The Uniform Environmental Covenants Act (UECA) allows for the long-term enforcement of clean-up controls (e.g., restrictions on certain uses, prohibitions on using wells, protection of caps, long-term maintenance, etc.) that are contained in a statutorily-defined, voluntary agreement know as an "environmental covenant" which will be binding on current owners and subsequent purchasers and tenants of the property and be listed in the local land records.	This Act is applicable for any remedy that includes establishing a Uniform Environmental Covenant (UEC).
Delaware Hazardous Substance Cleanup Act and the Delaware Regulations and Remediation Standards Guidance Governing Hazardous Substance Cleanup	Title 7 Delaware Code Chapter 91	The Hazardous Substance Cleanup Act (HSCA) regulations establish the administrative processes and standards to identify, investigate, and cleanup facilities with a release or imminent threat of release of hazardous substances.	HSCA and its enabling regulations and guidance are the primary drivers to this document, to the previous evaluations of the site, and to site closure.
Delaware Regulations Governing Solid Waste	Title 7 Delaware Administrative Code Section 1301	The Delaware Regulations Governing Solid Waste apply to any person using land or allowing the use of land for the purposes of storage, collection, processing, transfer, or disposal of solid waste; and to any person transporting solid waste in or through the State of Delaware.	These regulations may be applicable if any wastes are generated during the implementation of the selected remedy.

Table 1-4 (continued)

Potential Action-Specific Applicable Local, State, and Federal Requirements for OU2

Requirement	Citation	Content/Purpose	Applicability for OU2
Clean Water Act	33 U.S.C. Section 1251 et seq. [1972])	The Clean Water Act (CWA) establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters.	The substantive requirements of the National Pollutant Discharge Elimination System (NPDES) (40 CFR Parts 122 through 125) are applicable to alternatives that would include remedial construction activities that could impact stormwater quality and remedies that generate water requiring treatment before being discharged to surface water. If more than one acre of soil is disturbed by a proposed remedy, a Stormwater Pollution Prevention Plan would be required. The substantive requirements of the General Pretreatment Regulations for Existing and New Sources of Pollution (40 CFR Part 403) would be applicable to alternatives that would include treated water discharges to a publicly-owned treatment works but is not an option for this site.
Delaware Regulations Governing the Control of Water Pollution	Title 7 Section 7201	These regulations seek to prevent, manage and/or control the pollution from activities that affect or have the reasonable potential to affect the quality of surface and ground waters. They implement the provisions of the federal CWA.	These regulations apply to point and non-point sources of pollution and to stormwater.

Table 1-4 (continued)

Potential Action-Specific Applicable Local, State, and Federal Requirements for OU2

Requirement	**Citation**	**Content/Purpose**	**Applicability for OU2**
Clean Air Act	42 U.S.C. Section 7401 et seq. [1970]	The Clean Air Act (CAA) and its amendments are the comprehensive federal laws that regulate air emissions from stationary and mobile sources. The CAA is implemented through the Delaware State Implementation Plan (SIP) and Delaware's Air Regulations (see below).	This Act is applicable for any remedy that might result in the discharge of air contaminants into the atmosphere.
State of Delaware Implementation Plans (SIPs) for Attainment and Maintenance of National Ambient Air Quality Standards (NAAQS)	Codified at 40 CFR Section 52, Subpart I	These SIPs and regulations establish ambient air and emissions standards at the state and county level and set forth the permitting requirements for equipment and construction activities that might discharge air contaminants into the atmosphere. The Delaware SIP for Attainment and Maintenance of NAAQS established standards for total suspended particulate matter (TSP), and for PM_{10} and $PM_{2.5}$ particulates. The regulations control particulate emissions during excavation activities.	This Act is applicable for any remedy that might result in the discharge of air contaminants into the atmosphere.
Delaware Regulations Governing the Control of Air Pollution	Title 7 Chapter 60		
Ambient Air Quality Standards	Title 7 Chapter 1103		
Regulations Governing Particulate Emissions from Construction and Materials Handling	Title 7 Chapter 1106		

Table 1-4 (continued)

Potential Action-Specific Applicable Local, State, and Federal Requirements for OU2

Requirement	Citation	Content/Purpose	Applicability for OU2
Federal Endangered Species Act	16 U.S.C. Section 1531 et seq.)	The Endangered Species Act (ESA) provides a program for the conservation of threatened and endangered plants and animals and the habitats in which they are found.	The potential presence of threatened, endangered, or otherwise protected species at the site and potential adverse impacts of remediation on those species would be considered in the evaluation of remedial alternatives.
Occupational Safety and Health Act	29 U.S.C. Section 651 et seq. [1970])	The purpose of the Occupational Safety and Health Act is to ensure worker and workplace safety. The Act is administered and enforced by the Occupational Safety and Health Administration (OSHA).	The Hazardous Waste Operation and Emergency Response Standard (29 CFR 1910.120) and Construction Industry Standard (29 CFR 1926) are applicable to operations conducted during remediation.
Delaware Regulations Governing the Control of Water Pollution	Title 7 Delaware Administrative Code Section 7201	These regulations seek to prevent, manage and/or control the pollution from activities that affect or have the reasonable potential to affect the quality of the surface and ground waters of the State of Delaware. These regulations include requirements for permits and monitoring.	The substantive provisions of these regulations are applicable for remedial actions involving treatment system discharges to surface water, as well as for stormwater discharges.
Delaware Sediment and Stormwater Regulations	Title 7 Delaware Administrative Code Section 5101	These regulations establish a statewide sediment and stormwater program to prevent existing water quantity and water quality problems resulting from stormwater runoff as a source of pollution to waters of the State.	The substantive provisions are applicable to stormwater from the Site during and after implementation of any remedial action.

Table 1-4 (continued)

Potential Action-Specific Applicable Local, State, and Federal Requirements for OU2

Requirement	Citation	Content/Purpose	Applicability for OU2
Sussex County Sediment Control & Stormwater Management, Ordinance No. 769	Delaware Code Chapter 90)	This ordinance establishes a sediment control and stormwater management program for Sussex County, and is implemented by the Sussex Conservation District's Sediment Control and Stormwater Management Program and Handbook.	Responsibility for implementation of this program with respect to this site has been deferred by Sussex County to DNREC's sediment and stormwater program.
Delaware Regulations Governing the Construction and Use of Wells	Title 7 Delaware Administrative Code Section 7301	These regulations establish requirements governing the location, design, installation, use, disinfection, modification, repair, and abandonment of all wells and associated pumping equipment as well as certain requirements for the protection of potable water supply wells.	The substantive provisions of these regulations are applicable to the construction, modification, and abandonment of monitoring wells.
Delaware Regulations for Licensing Water Well Contractors, Pump Installer Contractors, Well Drillers, Well Drivers, and Pump Installers	Title 7 Delaware Administrative Code Section 7302	These regulations provide for the examination and licensure of persons engaged in drilling, boring, coring, driving, digging, construction, installation, removal, or repair of wells and test well; and abandoning, sealing, and/or modifying wells and test wells.	Any such drilling, installation, or abandonment activities pertaining to monitoring wells would be conducted by properly licensed workers.
Delaware Regulations Governing the Control of Noise	Title 7, Sections 1149 and 7105	These regulations address the non-vehicle aspects of noise control, establishing that no sound levels at receiving property lines shall exceed 85 dBA for a period of one hour, and no work between 10 PM and 7 AM.	These regulations are applicable for noise generated by remedy construction activities.

Table 1-4 (continued)

Potential Action-Specific Applicable Local, State, and Federal Requirements for OU2

Requirement	Citation	Content/Purpose	Applicability for OU2
Town of Millsboro Regulations Chapter 210, Zoning, Article V (General Provisions), Section 41 (Performance Standards), 210-41F, Noise		Establishes maximum permissible sound pressure levels for smooth and continuous noise at property lines or along public rights-of-way. It also establishes corrections to permissible sound pressure levels if the noise is not smooth and continuous, or if the noise is between 7 AM and 10 PM. "Nuisance" noise is not permitted.	These regulations are applicable for noise generated by remedy construction activities.
Town of Dagsboro Charter, Chapter 173, Noise, Ordinance No. 72, June 18, 2001		Loud, unnecessary or unusual noises are prohibited. This includes the operation of a machine or device in such a manner as to be plainly audible or unreasonably loud to a reasonable person or persons of normal sensitivities at a distance greater than 25 feet from the property line of where the machine or device is located.	This ordinance is applicable for noise generated by remedy construction activities.

Notes:

CAA – Clean Air Act

CFR – Code of Federal Regulations

CWA – Clean Water Act

DNREC – Delaware Department of Natural Resources and Environmental Control

ESA – Endangered Species Act

HSCA – Hazardous Substances Cleanup Act

NAAQS – National Ambient Air Quality Standards

NPDES – National Pollutant Discharge Elimination System

OSHA – Occupational Safety and Health Administration

TSP – total suspended particulate matter

UEC – Uniform Environmental Covenant

UECA - Uniform Environmental Covenants Act

USC – U.S. Code

1.3 Remedial Action Objectives

The RAOs describe the expected condition and contaminant levels at the Site following remediation. The qualitative and quantitative RAOs for OU2 listed in this section were developed in coordination with DNREC-SIRS prior to the commencement of this FS. The RAOs establish the expectations (i.e., performance criteria) for the remedial alternatives considered in this FS.

1.3.1 Qualitative

1. Minimize human cancer risks and non-cancer hazards from exposure to soil.
2. Minimize migration of constituents of concern (COCs) from OU2 to other OUs or off-site, including:
    a. Air to surface water or sediment.
    b. Runoff/erosion to surface water or sediment.
3. Reduce ecological risk (to terrestrial populations and communities) to lowest practicable levels.
4. Minimize unnecessary injuries to natural resources resulting from remedial action.
5. Ensure no significant degradation of groundwater, surface water, or sediment quality beyond existing levels.

1.3.2 Quantitative

1. Ensure human cancer risk is less than 1×10^{-5}.
2. Ensure human non-cancer Hazard Index (HI) is less than 1.

1.4 Volumes of Contaminated Media

The *in situ* volume of ash at the Site was estimated using the AutoCAD software program. The volume estimate includes areas identified as OU1 and OU2. The 'top' of the ash was based on the surface elevation map generated from the 2005-2006 topographical survey. The horizontal extent of the ash was input as either the mean low water interface with the shoreline (in areas where the tidal zone occurred at the base of the berms) or the base of the slope (in areas where flat wetlands extended away from the berms into the waterway). The horizontal extent includes the area of the ponds on the eastern end of OU2. The vertical extent of the ash was input as a range. The low end estimate assumed a fixed 'bottom' of ash at elevation zero (mean low water elevation is zero). The high end estimate assumed that the 'bottom' of ash varied based on the results of soil borings conducted for the FE (Shaw, 2008). In this variable depth scenario, the horizontal extent represented by each boring was interpreted. The estimated *in situ* volume of ash at the Site ranges between 1.903 and 1.987 million cubic yards. The results of the volume calculation are depicted in **Figure 1-7**.

The majority of, if not the entire existing volume of ash at the Site is in OU2 because ash was removed from OU1 during implementation of the shoreline stabilization project. During the installation of the stone revetment as part of the first phase of shoreline stabilization project in OU1, ash material cut from the slopes to achieve desired grades was hauled off-site for disposal at the current landfill. Ash material removed for grading during the second phase of the project was moved to a designated spoils disposal area in OU2.

A settled or compacted soil will increase in volume as air is incorporated during an earth moving disturbance. Based on the soil type at OU2, the *ex situ* volume is anticipated to be approximately 25 percent greater than the estimated *in situ* volume. This bulking factor will be considered in the remedial alternatives for OU2 that include soil disturbance. This applies to material handling considerations of both imported soil compacted on site or exported soil.

2.0 Development of Remedial Action Alternatives

Remedial alternatives address contamination on a site-wide basis and are developed from media-specific remedial technologies and process options. The evaluation and screening process involves the following steps:

- Identification of remedial response actions;
- Identification and screening of remedial technologies and process options; and
- Development of remedial alternatives.

General response actions are identified in Section 2.1. Technology types and process options are identified and screened based on technical practicability, likely effectiveness, operational ease, reliability, and cost in Section 2.2. The process options that remain after screening are used in assembling remedial alternatives for OU2 as described in Section 2.3.

The identification and screening of general response actions, technology types, and process options presented in this section are based on data and technical information obtained through professional experience and various USEPA technical memoranda and guidance documents including *In Situ Treatment Technologies for Contaminated Soil* (USEPA, 2006); *Technology Screening Guide for Treatment of CERCLA Soils and Sludges* (USEPA, 1988a); and *Feasibility Study Analysis for CERCLA Municipal Landfill Sites* (USEPA, 1994).

2.1 Identification of General Response Actions

General response actions are generic types of remedial actions specific to media (i.e., soil, sediment, surface water, etc.) that can, alone or in combination, achieve the established RAOs for the site. A general response action may consist of several technology types that can potentially consist of several process options. The general response actions identified for soil at OU2 that alone or in conjunction with other response actions could potentially achieve RAOs include the following:

- **No Action.** No action implies that the site is left in its present condition. This general response action provides a baseline response for comparison to the other remedial response actions. The National Contingency Plan requires that "no action" be included among the general response actions evaluated [40 CFR 300.430(e)(6)].

- **Land Use Controls.** Land use controls include any type of physical, legal, or administrative mechanism that restricts the use of, or limits access to, real property to prevent or reduce risks to human health and the environment. Institutional controls are a subset of land use controls. Land use controls may reduce human health risks from site contaminants by restricting access, land use, or activities at the site. Land use controls typically will not reduce ecological risks by themselves. While exposure pathways may be interrupted, the contaminated material is not remediated.

- **Containment.** Containment refers to physical processes that would restrict contaminant mobility and/or exposure potential without changing their toxicity or volume. Containment protects human health and minimizes ecological risk by controlling both contaminant migration and the routes of potential exposure.

- **Removal.** Removal includes physically removing contaminated media as an initial step for on-site or off-site treatment and/or disposal at another location. Removal can mitigate exposure pathways; however, it has no effect by itself on the toxicity or volume of contaminated material.

- **Treatment.** Treatment may include any physical, chemical, biological, or thermal processes that would lower human health or ecological risk from the contamination by their destruction or conversion into less hazardous forms. The result is a reduction in the toxicity, mobility, or volume of contaminated material. Treatments can be performed either *in situ* or *ex situ*.

Applicable technologies associated with each of these general response actions are discussed in the following section.

2.2 Identification and Screening of Technology Types and Process Options

A range of technology types and process options was identified and screened according to their overall applicability to the primary contaminants and conditions present at the site. The retained technologies were then screened based on effectiveness, implementability, and cost. These primary and secondary screening processes are described in this section.

The identification and screening of technology types and process options are limited to general response actions for soil. As discussed in Section 1.2.5.1, the identified potential human health risk to the child trespassing recreational fisherman was a result of the cumulative effect of ingestion of fish/shellfish, incidental ingestion of soil, and dermal absorption of soil. Fish/shellfish ingestion was assessed in conjunction with OU1 and OU3 in the FE (Shaw, 2008) and it was determined that the “level of contamination present at Burton Island did not pose an undue health risk to an adult or child who may be exposed to the contaminants from eating fish from the local waters” (DNREC, 2008). Therefore, potential human health risk would be mitigated by addressing OU2 soil. Although the potential ecological risk discussed in Section 1.2.5.2 results from a more complex interaction of ecological receptors with OU2 than for the human receptor, a general response action for OU2 soil that limits the potential risk associated with ingestion or contact with the soil can meet the RAOs.

There is no immediate risk driver to address the ponds at OU2 (Section 1.2.3) or groundwater (Section 1.2.4). As such, no pond sediment, pond surface water, or groundwater specific response actions need to be considered at this time. Depending on the technology types and process options retained for consideration in a remedial alternative, a soil-based response action may also result in risk reduction for other media. Additional components of remediation, such as site restoration and specific design considerations for implementing a remedial action for soil in the area of the ponds at OU2, are discussed in the description of remedial alternatives presented in Section 2.3.2. Implementing measures to control any ongoing sources, such as the ash material in soil, and evaluating the effectiveness of those controls is the first step for any remediation at OU2. Until this is done, evaluating other actions specific for pond sediment, pond surface water, or groundwater is not appropriate. The affect of implementing any alternative for soil on the potential future applicability of remediation of other media is identified in the screening of alternatives in Section 3.0.

2.2.1 Primary Screening

For each general response action, one or more technology types and associated process options were identified that could potentially contribute to achieving RAOs. The technology types and process options were first screened based on technical practicability. The primary factors in this screening step include applicability of processes to OU2 soil (i.e., limited soil mixed with fine-grained fly ash), OU2 soil COCs (i.e., arsenic, barium, mercury, selenium, and thallium), and OU2 subsurface conditions (i.e., homogenous, shallow water table, and surrounding saline waters). As stated in the HSCA Guidance (DNREC, 1994), innovative approaches were emphasized where possible and innovative process options were retained where practicable. The initial screening results for soil at OU2 are summarized in **Table 2-1** at the end of Section 2.2.1.

The technology types and process options considered for soil at OU2 include the following:

- **No Action**
- **Land Use Controls**
  - Institutional controls: surveillance/perimeter patrols, signage, and land use restrictions
  - Physical access restrictions: fencing
- **Containment**
  - Cap: clay; asphalt/concrete; and multi-layer, multi-media
  - Cover: soil cover
  - Vertical barriers: slurry wall and sheet piling
- **Removal**
  - Excavation
- **Treatment**
  - *In situ* physical treatment: soil vapor extraction, electrokinetic separation, and vitrification
  - *In situ* chemical treatment: soil flushing and solidification/stabilization
  - *In situ* thermal treatment: radio frequency heating or 3 and 6 phase heating and steam injection or heating rod heating
  - *In situ* biological treatment: enhanced bioremediation and phytoremediation
  - *Ex situ* chemical treatment: chemical extraction, soil washing, chemical reduction/oxidation, and solidification/stabilization
  - *Ex situ* biological treatment: composting

- *Ex situ* thermal treatment: incineration and pyrolysis

The technology types and process options that will not be retained for further consideration are highlighted with hatch marks in **Table 2-1**. For soil at OU2, the eliminated process options and the primary rationale for elimination include the following:

- Not applicable for OU2 soil (i.e., limited soil mixed with fine-grained fly ash): sheet piling vertical barrier, *in situ* chemical treatment by soil flushing, and *ex situ* chemical treatment by soil washing. The human health risk drivers for the site are ingestion of or dermal absorption of the OU2 soil. The sheet piling vertical barrier is a technology that would not mitigate potential risk of exposure to surface soils. Sheet piling vertical barriers were eliminated from further consideration. Soil flushing is an *in situ* treatment technology with the primary function of removing COCs from the aqueous phase. Soil flushing will not effectively treat COCs in soil or decrease the potential risk of exposure to residual OU2 soils and was not retained for further consideration. Soil washing is an *ex situ* treatment technology that simply separates ash/coal from indigenous soil. Effectiveness of soil washing is questionable for a fine-grained fly ash mix and was not retained for further consideration.

- Not applicable for OU2 soil COCs (i.e., arsenic, barium, mercury, selenium, and thallium): *in situ* physical treatment by soil vapor extraction; *in situ* biological treatment by enhanced bioremediation; *in situ* thermal treatment by radio frequency heating, 3 and 6 phase heating, steam injection, or heating rod heating; *ex situ* chemical treatment by chemical reduction/oxidation; *ex situ* biological treatment by composting; and *ex situ* thermal treatment by incineration or pyrolysis. None of these treatment technologies can reliably reduce bioavailability and/or long-term solubility of COCs from OU2 soil and were not retained for further consideration.

- Not applicable for OU2 subsurface conditions (i.e., homogenous, shallow water table, and surrounding saline waters): slurry wall vertical barrier and *in situ* physical treatment by electrokinetic separation or vitrification. These treatment technologies are not practicable to implement in the presence of water or elevated sulfate concentrations (i.e., saline water) and were not retained for further consideration.

The technology types and process options that were identified as practicable for soil at OU2 in **Table 2-1** include no action; land use controls in the form of land use restrictions, signage, surveillance/perimeter patrols, and fencing; containment with cap or cover; removal via excavation; *in situ* and *ex situ* chemical treatment by solidification/stabilization; *in situ* biological treatment by phytoremediation; and *ex situ* chemical treatment by chemical extraction. These options will be retained for the second screening step. Note that although phytoremediation has limited potential applicability for select COCs in shallow soils at OU2, this process option was retained for further screening as an innovative treatment approach.

Table 2-1

Primary Screening of Technologies and Process Options for Soil at OU2

Soil General Response Actions	Remedial Technology Types	Process Options	Description	Screening Comments
No Action	None	Not applicable	No action.	Required for consideration by NCP.
Land Use Controls	Institutional Controls	Surveillance/perimeter patrols	Conduct surveillance and manual perimeter patrols to deter unauthorized land use.	Potentially applicable.
		Signage	Post signs.	Potentially applicable.
		Land use restrictions	Future land use restrictions (e.g., deed restrictions) limiting future land use.	Potentially applicable.
	Physical Access Restrictions	Fencing	Install perimeter fence.	Potentially applicable.
Containment	Cap	Clay cap	Compacted clay covered with soil over areas of contamination.	Potentially applicable.
		Asphalt/Concrete cap	Application of a layer of asphalt or poured concrete over areas of contamination.	Potentially applicable.
		Multi-layer, multi-media cap	Clay and synthetic membrane covered by soil over areas of contamination.	Potentially applicable.
	Cover	Soil cover	Soil cover over areas of contamination.	Potentially applicable.
	Vertical Barriers	Slurry wall	Trench around areas of contamination is filled with a soil (or cement) bentonite slurry.	Not applicable for shallow water table conditions and close proximity to sizeable surface waters.
		Sheet piling	Vibrating force to advance steel sheet piles into the ground around areas of contamination.	Limited applicability for management of horizontal soil or constituent of concern (COC) migration. Technology more appropriate for groundwater management and not applicable for mitigating potential soil exposure.

Table 2-1 (continued)
Primary Screening of Technologies and Process Options for Soil at OU2

Soil General Response Actions	Remedial Technology Types	Process Options	Description	Screening Comments
Removal	Excavation	Solids excavation	Remove contaminated solids.	Potentially applicable. Requires identification of treatment or disposal location on-site or off-site for large volume of soil. Excavation area restoration required.
In Situ Treatment	Physical Treatment	Soil vapor extraction (SVE)	Vacuum applied to extraction wells induces movement of gas-phase volatiles to collection for treatment.	Not applicable to COCs (i.e., As, Ba, Hg, Se, Th) found in soils at OU2 as they are not volatile at SVE conditions.
		Electrokinetic separation	Apply low-intensity, direct current through soil to separate and extract contaminants.	Limited applicability for treating COCs (i.e., As, Ba, Hg, Se and Th) found in soils at OU2; not applicable in saturated soils or soil with high salinity.
		Vitrification	Apply heat to convert mass into glass	Not applicable in saturated soils or soil with high salinity.
	Chemical Treatment	Soil flushing	Inject water, cosolvent, or chelants through contaminated area and collect liquid from the subsurface for further treatment.	Limited applicability for fine-grained soils (i.e., ash). Technology most effective for treating aqueous phase.
		Solidification / stabilization	Add binders to encapsulate soil thereby minimizing access to soil and to mechanically or chemically interact with the contaminants to limit their solubility or mobility.	Potentially applicable.
	Thermal Treatment	*Radio frequency heating or 3 and 6 phase heating*	Use electromagnetic energy and electrical resistance to heat soils and enhance SVE performance.	COCs (i.e., As, Ba, Hg, Se, Th) found in soils at OU2 are not readily volatized. Technology is not normally applied to tidally influenced shallow groundwater sites.

Table 2-1 (continued)

Primary Screening of Technologies and Process Options for Soil at OU2

Soil General Response Actions	Remedial Technology Types	Process Options	Description	Screening Comments
In Situ Treatment (continued)	Thermal Treatment (continued)	*Steam injection or heating rod heating*	Inject steam below the zone of contamination or insert heating rods into the soil to release contaminants from soil and migrate upwards to be collected with an SVE system.	COCs (i.e., As, Ba, Hg, Se, Th) found in soils at OU2 are not readily volatized. Technology is not normally applied to tidally influenced shallow groundwater sites.
	Biological Treatment	*Enhanced bioremediation*	Circulate water-based nutrients through the soil in place. Indigenous microbe population will be enhanced to modify the redox conditions and/or convert the metals to less soluble sulfides (i.e., alter COC speciation to minimize COC solubility, mobility, and bioavailability).	This treatment for soil is most effective in the saturated zone. The redox condition of groundwater at OU2 is aerobic. It is not practicable to attempt to achieve and maintain a reductive environment with a shallow groundwater that is tidally influenced.
		Phytoremediation	Introduce plants to remove contaminants from impacted soils through natural biological processes.	Potentially applicable for select COCs in shallow soil (i.e., root zone) only. Vegetation growth limited by growing season and fine-grained soils (i.e., ash). Treatment residuals (i.e., vegetation) make COCs more available to enter ecosystem through food chain (e.g., birds and other wildlife may eat the vegetation).
Ex Situ Treatment	Chemical Treatment	*Chemical extraction*	Uses acid or chelants to extract heavy metal contaminants, or cosolvents for other constituents, from soils. Extractant and wash liquids require further treatment.	Extensive testing required to determine the correct conditions and extractant to use for successful application. Potentially applicable. Soil removal for treatment and handling for disposal required (see Removal).

Table 2-1 (continued)
Primary Screening of Technologies and Process Options for Soil at OU2

Soil General Response Actions	Remedial Technology Types	Process Options	Description	Screening Comments
Ex Situ Treatment (continued)	Chemical Treatment (continued)	*Soil washing*	Mix soils in reactor to detach contaminants from soil. Extractant requires further treatment.	Soil washing typically uses size fractionation to isolate the contaminated size fraction. Not practicable for fine-grained soils (i.e., ash). Soil removal for treatment and handling for disposal required (see Removal).
		Chemical reduction / oxidation	Apply chemical oxidants or reductants to modify the COC speciation to minimize COC solubility, mobility, and bioavailability.	Technology most effective for treating aqueous phase with limited applicability for soil. Extensive testing required to identify a single additive, if any, that is applicable to all COCs (i.e., As, Ba, Hg, Se, Th) in order to reduce their bioavailability. Soil removal for treatment and handling for disposal required (see Removal).
		Solidification / stabilization	Add binders to encapsulate soil thereby minimizing access to soil and to mechanically or chemically interact with the contaminants to limit their solubility or mobility.	Potentially applicable. Soil removal for treatment and handling for disposal required (see Removal).
	Biological Treatment	*Composting*	Combine contaminated soil with readily degradable carbon sources, bulking agents, and nutrients to decrease COC solubility and bioavailability. Indigenous microbe population will be enhanced to modify the redox conditions and/or convert the metals to less soluble sulfides (i.e., alter COC speciation to minimize COC solubility and bioavailability).	Limited applicability for soil treatment due to difficulty identifying and maintaining single aerobic or anaerobic condition to treat all COCs (i.e., As, Ba, Hg, Se, Th) found in soils at OU2. Soil removal for treatment and handling for disposal required (see Removal).

Soil General Response Actions	Remedial Technology Types	Process Options	Description	Screening Comments
Ex Situ Treatment (continued)	Thermal Treatment	*Incineration*	Chemical decomposition of organic compounds and metal speciation changes induced by heating at high temperatures.	Not applicable to COCs (i.e., As, Ba, Hg, Se, Th) found in soils at OU2. Soil removal for treatment and handling for disposal required (see Removal).
		Pyrolysis	Chemical decomposition of organic compounds and metal speciation changes induced by heating at high temperatures in the absence of oxygen.	Not applicable to COCs (i.e., As, Ba, Hg, Se, Th) found in soils at OU2. Soil removal for treatment and handling for disposal required (see Removal).

Note(s):

*Shaded cells indicate that the remedial technology type and/or process option was eliminated from further evaluation.
COC – constituent of concern
NCP – National Contingency Plan
O&M – operation and maintenance.
SVE – Soil Vapor Extraction

2.2.2 *Secondary Screening*

The technology types and process options that were retained after the primary screening were screened in a second step based on likely effectiveness, overall implementability, and relative cost. The screening criteria are briefly defined below:

- **Effectiveness** – The reliability of a technology to meet defined RAOs for protection of human health and the environment and address the volume of impacted media given site conditions.

- **Implementability** – Technical and administrative feasibility of implementing the technology. Technical feasibility was evaluated in the first screening step (**Table 2-1**). Administrative feasibility includes the ability to meet substantive provisions of permit requirements; the availability of treatment, storage, and disposal services; and the availability of necessary equipment and skilled workers to implement the technology.

- **Cost** – A relative estimate of the cost of implementing the technology based on engineering judgment and available reference sources. The estimate includes capital, and operation and maintenance (O&M) costs.

Based on this evaluation, the technology type or process option is either retained for further evaluation in a remedial alternative or eliminated. The screening results are summarized in **Table 2-2** at the end of Section 2.2.2. The technology types and process options included in **Table 2-2** are described in further detail below. Process options that are screened out from further consideration are highlighted with hatch marks in **Table 2-2**.

No Action

The No Action response action is required to be retained as a baseline for comparison. This response action would not be effective in minimizing potential human health or ecological risks. As there is no active remediation, this response action is easy to implement and has no associated monetary cost.

Land Use Controls

Land use controls would restrict access to OU2, or other designated areas to be protected, through administrative and/or physical barriers. Land use controls do not address the impacted media but instead limit a pathway of potential exposure. Administrative means would include implementation of land use restrictions (i.e., institutional controls), signage, and surveillance/perimeter patrols. Physical barriers would include fencing.

Land use restrictions (i.e., institutional controls) are not typically considered as a stand-alone process option but rather as a general method used in combination with other process options to enforce other land use controls. Land use restrictions in the form of a Uniform Environmental Covenant (UEC) would legally limit future use of OU2. No digging or other disturbance of OU2 would be permitted under the covenant. Establishing the UEC would require legal support and coordination between NRG and

DNREC to develop the language. This legal document would be recorded on the property deed. As such, a UEC is relatively easy to implement. It is effective for limiting land use provided it is enforced.

Signs, surveillance/perimeter patrols, and fencing would limit human access to OU2 and would discourage trespassing or other unauthorized land use. Signs, surveillance/perimeter patrols, and fencing can be effective in minimizing potential human health risk. These controls would not change potential ecological risks except possibly for larger terrestrial animals unable to access OU2 through or over a fence. Fencing would provide a continuous barrier at all times. 'No Trespassing Private Property' signs are currently posted at the top of the shoreline slope of OU2 at an approximate 200-foot spacing in areas stabilized during the first phase of revetment construction. NRG currently conducts periodic patrols of the shoreline for stone revetment inspections. Landside access to OU2 is controlled via 24-hour security guards, fence, and locked gates at the entrance to the plant; fencing around the facility; additional fencing and a locked gate at the entrance to the Site; and 'no trespassing private property' signs are posted sporadically on the perimeter of OU2. There are numerous contractors and materials available to install and maintain signs or a fence at OU2 and facility personnel are available to perform perimeter patrols.

Surveillance in the form of electronic monitoring would be more difficult to implement and maintain than perimeter patrols because there currently is no power source at OU2. Also, as the equipment would likely be positioned to monitor the shoreline, the primary access route for trespassers, it would be subject to weather conditions and salt spray. This exposure would reduce visibility and increase the effort for maintenance. Perimeter patrols could be conducted by a variety of personnel already at the facility or by a contracted party for weekend and holiday coverage, if necessary.

Fencing may be difficult to install at the perimeter of OU2 due to the tradeoffs between working on the shoreline topography and maximizing enclosed area. The shoreline consists of the stone revetment in OU1 nearest the water, a graded slope covered with topsoil and vegetation, and a perimeter access road with an unimproved pervious surface. A fence installed at the top of the stone revetment positioned in OU1 will maximize the area of OU2 enclosed within the fence thereby minimizing potential risk for trespassers of exposure to soil at OU2. However, installing fence posts at or near the bottom of a slope and at or behind the buried stone would be difficult (i.e., limited footing on slopes and obstructed digging around stone). Maintenance of the fence in this location would be difficult as it is only accessible by traversing the slope on foot which increases potential for wear and erosion of the slope. Access to the stone revetment for potential future maintenance would be hindered by the presence of a fence located waterward of the access road. Because the slopes above the stone revetment already have topsoil and vegetative cover, the fence could be installed at the top of the slope without significantly increasing the potential risk of exposure for trespassers to soil at OU2. Fence would be easier to install and maintain at this location; however, access to the slope as well as the revetment for potential future maintenance would be hindered by the presence of a fence waterward of the access road. The fence posts are also subject to washout over time when installed at the top of a slope if additional stormwater controls for areas inside the fence are not also maintained. Alternatively, locating the fence inside the perimeter access road would be easiest to install and maintain, most resistant to washout, and not a hindrance to potential future maintenance of the shoreline stabilization project. This fence location would, however, allow trespassers access to the unimproved surface of the perimeter access road.

Land use controls are effective for minimizing potential human health risks from exposure to OU2 soil, implementability is relatively easy, and cost is relatively low. Therefore, land use controls will be retained for further consideration as part of a remedial alternative.

Containment – Caps and Cover

The containment response option will limit exposure to surficial impacted media and could consist of an impermeable cap or a permeable cover. Caps are typically constructed of clay, asphalt, or concrete, or are of multi-layer and multi-media construction. A multi-layer and multi-media cap is typically constructed of a variety of natural and man-made materials to achieve the functions of a low-permeability layer, a drainage layer, and a vegetative/topsoil layer. Except for grasses on the soil cover of clay and multi-media caps, caps are typically devoid of vegetation as penetrating roots can jeopardize the cap's integrity. A cover is typically constructed of soil with vegetation for stabilization. Construction of a cap or cover would require a permitted engineering design, removal of vegetation, grading the surface with heavy machinery to achieve the necessary slopes for stability and stormwater management, and importing materials for construction.

Capped and covered areas should not be disturbed (e.g., vehicular traffic) as it could jeopardize the integrity of the cap or cover. Depending on multiple factors, cap maintenance may be more intensive than for soil cover. The caps may be subject to cracking (e.g., concrete and asphalt), weathering (e.g., concrete), or root penetration (e.g., clay). In addition, an impermeable cap may adversely affect groundwater flow at the site depending on the extent of capped area. For example, an impermeable cap may affect the wetlands adjacent to OU2 by controlling infiltration of precipitation flow and significantly altering the current groundwater flow. A properly designed soil cover does not suffer these limitations. A properly constructed and maintained containment response action would be effective in minimizing human health and ecological risks by reducing potential exposure to OU2 soil. In addition, migration of ash material in soil from the surface of OU2 would be minimized by the presence of a cap or cover. However, there is no resulting reduction in toxicity or volume of contaminated media.

The sole function of a soil cover and primary function of a cap is to limit direct contact with impacted material. For OU2, minimizing exposure to impacted surface soil is required to achieve the RAOs. Installation of a soil cover or cap would be effective in minimizing human health and ecological risks by limiting potential exposure to ash material in soil. In addition, other RAOs would be achieved by minimizing potential migration of ash material in soil in wind or stormwater runoff through installation of a soil cover or cap. Potential risks to construction workers include exposure to ash material during construction and other materials handling related hazards.

Generally, construction of an impermeable cap is moderately implementable because it is a complex yet well practiced technology and numerous skilled contractors are available. Procurement of the necessary materials may be more challenging for implementation of a clay cap as compared to asphalt, concrete, or multi-media caps because local sources of sufficient clay are limited. In addition, existing fly ash material in soil at OU2 may be useable in either concrete or asphalt caps as filler. Both covers and caps would require an engineering design to identify proper materials and construction details, procurement of materials, vegetation clearing and grubbing, grading with earth moving equipment, and application. Grading and quality of construction of an impermeable cap are critical to adequately manage stormwater runoff and ensure long-term durability. However, a soil cover may be more easily implemented than a cap because of the flexibility in layout. It could more easily be applied in discrete areas with minimal vegetation, habitat, and wildlife disturbance or grading such as around larger established trees. In addition, stormwater management is not as significant an issue for a permeable cover which may minimize engineering and grading efforts.

The containment response actions are costly to install due to the required engineering, permitting, procurement of materials, expertise in construction, labor, and equipment. Impermeable caps are significantly more costly than covers for site preparation and construction. In addition to capital costs, the O&M costs can be significant in terms of long-term monitoring and repair. In increasing order of approximate relative total cost, the containment response actions are soil cover, clay cap, asphalt/concrete cap, and multi-layer, multi-media cap. While clay caps are typically the least expensive of the capping options to implement, the volume of clay required may be limiting and the distance to the clay source from this location may be significant, thus, driving up the cost.

The caps are eliminated from further consideration in the development of remedial alternatives as it is not necessary, or desirable, to control infiltration of precipitation at OU2 to achieve RAOs and due to the high relative cost of caps compared to soil cover. The soil cover process option will be retained for further consideration as part of a remedial alternative.

<u>Removal</u>

Removal actions involve excavation of soil using conventional earth-moving equipment such as excavators and loaders. Removal actions would be used in conjunction with on-site or off-site treatment or off-site disposal.

Removal of OU2 would be effective in minimizing current human health and ecological risks at the site although the risk stays with the removed material. The disturbance of a removal action would eliminate existing vegetation, habitat, and wildlife. The technology poses potential risks to the community and construction workers from exposure during excavation and transportation and to construction workers for other materials handling-related hazards on site. This process option would achieve RAOs but at the same time significantly alter the existing landscape of the Site.

Despite the ready availability of conventional earth moving equipment and operators, this response action would be difficult to implement due to the large volume of material, limited equipment access through the active facility, and close proximity of OU2 to wetlands and waterways. Because the bottom of OU2 extends into and in several areas below the tidal surface water elevation, any removal action at this depth would also require engineered water infiltration and dewatering controls. In addition, management areas on the facility property are limited for the large volume of ash material in OU2 soil for either *ex situ* treatment or temporary stockpiling for disposal characterization. While off-site disposal options exist, it is likely that multiple locations would need to be utilized to accept the large volume of ash material in OU2 soil. The distance from the site to the nearest disposal facility will affect cost.

The capital cost is significant to not only remove ash material in OU2 soil as it is labor intensive but also to restore the nearly 100-acre excavation area. Restoration would be required to stabilize the newly exposed soil surface in the excavation area against erosion from surrounding surface waters and sedimentation from stormwater runoff. O&M costs are highly variable based on the restoration and disposal option selected and would include monitoring and possible repair for the restoration area and management of the removed material if treated on-site. Despite the high level of difficulty in managing the large volume of ash material in OU2 soil and the associated significant cost, this process option is retained for further consideration as part of a remedial alternative because of its nearly guaranteed effectiveness in achieving RAOs.

<u>Treatment - Solidification/Stabilization</u>

Chemical treatment in the form of solidification/stabilization is also known as fixation. This process option involves the addition of chemicals to solidify the ash material in OU2 soil (i.e., the soil becomes a soil-cement monolithic material after curing for several days) thereby stabilizing the soil and reducing contaminant mobility. This treatment can be performed either *in situ* or *ex situ*. Applying this process *in situ* requires the installation of injection points and use of moderate to large-scale augers or large earth moving equipment (e.g., excavators or tillers) to work the stabilizing agent into the soil. For *ex situ* applications, the soil is excavated, mixed with the stabilizing agent in tanks, containers, or pug mills, allowed to cure, and then disposed off-site, above ground in stockpiles on site, or placed back into the excavation area on site. Replacement in the excavation area would likely be the least costly disposal option.

Although this process option does not reduce contaminant toxicity, it could be effective in minimizing human health and ecological risks by eliminating the potential for ingestion and eliminating migration of ash material in soil. Performance of the process for certain metals is uncertain and a treatability study would be recommended before applying this technology for the COCs at OU2. Potential risks to construction workers include exposure to ash material during mixing and other construction and materials handling related hazards.

For this technology, solidification/stabilization additives are distributed through the entire contaminated area. A sufficiently large area for the on-site processing would need to be identified (*ex situ* application only). The volume of ash material in OU2 soil is large (as per Section 1.4). It is anticipated that approximately 5 to 20 percent by weight cement-based slurry or similar reagent would be required to effectively treat OU2. Depending on the specific additive, the process may result in up to a 10 percent increase in volume of treated ash material. If performed *in situ*, vegetation would not be able to grow on the solidified mass. If performed *ex situ*, mixing may be easier but implementation is made significantly more complex by the need to remove ash material in soil for treatment, dispose of the solidified mass (off-site or on-site), and restore the site as necessary.

The cost will not be insignificant for the permitting to inject or mix chemical additives in close proximity to wetlands and waterways (*in situ* application only), the procurement of the chemical additives, and the specialized expertise to administer the additives. Added costs for the *ex situ* application include material handling before and after treatment and site restoration as described previously for the 'Removal' process option. The O&M cost would likely include long-term monitoring and repair of the stabilized area (if not disposed off site) as it may be subject to weathering. In particular, salt spray from the surrounding surface waters may shorten the lifespan of the concrete.

This process option is potentially one of the more difficult to implement and is one of the most costly process options. Since controlling COC movement in groundwater or surface water is not an objective to achieve RAOs, and due to uncertainties with implementing this process option and its associated significant cost, this process option is eliminated from further consideration in the development of remedial alternatives.

In Situ Treatment - Phytoremediation

Phytoremediation is the use of select species of vegetation to remove certain chemicals from the root zone in soil when their roots take in water and nutrients for growth. In general, with phytoremediation, chemicals are either stored in the plants or in the biomass associated with the root area, or with some organic compounds, changed to gases and released to the air. In the case of the COCs at OU2 (i.e., arsenic, barium, mercury, selenium, and thallium), the metals would be stored in the plants or associated biomass. The smaller vegetation can then be harvested and destroyed while larger woody species (i.e., trees) used for phytoremediation are typically not harvested. The presence of the vegetation also helps to prevent wind and rain from transporting surface soil away from the site. Phytoremediation takes advantage of natural plant processes and reduces the need for machinery or other mechanical means of removing chemicals. The presence of vegetation is more aesthetically pleasing than other non-vegetated process options, however, it may take many years to be effective.

Phytoremediation may be effective over the long-term in removing the COCs from shallow soils only (i.e., within the root zone). However, the vegetation must then be managed as a waste material. Insects and small animals may eat the plants used for phytoremediation, thus, exposing them to concentrated COCs that they otherwise would only encounter through eating the soil. Risks to ecological receptors from eating the phytoremediation vegetation increase with time as each plant grows at the site and accumulates more COCs. The vegetation used for phytoremediation is selected specifically for most efficient COC uptake and is not necessarily a native species or what is currently growing at OU2. Phytoremediation would not be effective in achieving RAOs in the short-term as it takes many years for the vegetation to take in the COCs.

Phytoremediation would be difficult to implement at OU2 due to the limited growing season. The vegetation would die each winter and have to be replanted. Larger woody species (i.e., trees) would be dormant through the winter months. Phytoremediation would require ongoing O&M to ensure any damaged plants are replaced as well as to perform any harvesting cycles. The growth of the vegetation would be enhanced through the addition of topsoil and fertilizer on OU2 as desirable vegetation is slow to naturally become established in the fine-grained, high ash content soil of OU2. However, too much topsoil would limit root zone contact with ash material in soil. In addition, existing vegetation may need to be cleared or thinned to create adequate sunlight exposure for phytoremediation species, particularly if targeting the entirety of OU2 for treatment. A means of irrigation, either hand applied or as an automatic system, using fresh water from the opposite side of the facility would be required to establish and maintain healthy vegetation for successful phytoremediation.

The cost to purchase and plant vegetation is relatively low compared to process options that require more equipment; however, the necessary harvesting cycles and O&M required to collect and dispose of vegetation seasonally, replant annually, and maintain vegetation for phytoremediation can become significant due to the labor involved.

Phytoremediation is eliminated from further consideration due to the significant cumulative long-term O&M costs for a process option of limited effectiveness that has the potential to increase risk of exposure to COCs for ecological receptors.

Ex Situ Treatment – Chemical Extraction

Chemical treatment in the form of chemical extraction involves using acid or chelants to extract heavy metals from soils. Performance of *ex situ* chemical extraction would involve the following general steps: excavate soil; mix with acid or chelants in tanks; remove extractant; test soil to determine residual metals concentration; repeat mixing with acid/chelant, extractant removal, and testing as needed to achieve desired results; rinse treated soil with water to remove residual acid or chelants (repeat as necessary); incorporate additives as needed to adjust pH or otherwise restore acceptable soil chemistry; and dispose of treated soil off-site, above ground in stockpiles on site, or place back into the excavation area on site. Replacement in the excavation area may appear to be less costly than off-site disposal of treated soil; however, the final rinsing and pH adjustment steps may be more intensive (and thus more costly) to meet standards for use of the treated soil as fill.

This process option will reduce COC concentrations in ash material in OU2 soil and, thus, would be effective in minimizing potential human health and ecological risks from exposure to ash material in OU2 soil. Potential risks to construction workers include exposure to ash material during mixing and other construction and materials handling-related hazards.

For this technology, acid or chelants would be mixed with the large volume of ash material in OU2 soil (as per Section 1.4) in batches. A sufficiently large area for the on-site processing would need to be identified. A treatability study would be recommended before applying this technology for ash material in OU2 soil to identify the appropriate acid or chelant. In general, the volume of extractant typically required can be one-half to three times the volume of material to be treated and the volume of wash liquids can be up to three times the volume of the extractant. The volumes are dependent upon multiple factors including the starting and target COC concentrations and desired resulting soil chemistry. Implementation is made significantly more complex by the need to remove ash material in soil for treatment, dispose of the treated ash material (off-site or on-site), and restore the site as necessary as described previously for the 'Removal' process option. Both the extractant and wash liquids have to be contained and handled on-site and disposed of through further treatment on site or transportation off site. Vegetation would not be able to grow on the treated ash material without soil amendment as the natural soil structure will be altered as a result of the chemical extraction process. Specifically, the common soil components of iron and aluminum and any organics would have been stripped from the ash material. If the treated ash material is going to be reused on site, it will need to be enhanced with organic materials and nutrients and/or topped with sufficient quality topsoil to allow vegetative growth.

The costs will not be insignificant for the material handling before and after treatment, procurement of the chemical additives, the specialized expertise to administer the additives, and site restoration. Materials to be managed include the ash material, extractant, and wash liquids.

This process option is potentially one of the more difficult to implement and is one of the most costly process options. Due to uncertainties with implementing this process option and its associated significant cost, this process option is eliminated from further consideration in the development of remedial alternatives.

Table 2-2

Secondary Screening of Technologies and Process Options for Soil at OU2

Soil General Response Actions	Remedial Technology Types	Process Options	Effectiveness	Implementability	Cost	Screening Comments
No Action	None	Not applicable	Not effective	Easy	Low	Retained (required)
Land Use Controls	Institutional	Surveillance/perimeter patrols	Not effective for ecological receptors	Relatively easy	Moderate operations and maintenance (O&M)	Retained
		Signage	Not effective for ecological receptors	Easy	Low	Retained
		Land use restrictions	Not effective for ecological receptors	Relatively easy	Relatively low	Retained
	Physical Access Restrictions	Fencing	Not effective for ecological receptors	Moderate; no appropriate location on slope to install	Moderate capital, relatively low O&M	Retained
Containment	Cap	Clay cap	Effective and reliable, susceptible to root penetration. Adverse affect on surface water and groundwater flow.	Difficult; clay availability (volume and location)	High	Eliminated
		Concrete cap	Potentially susceptible to cracks and weathering. Adverse affect on surface water and groundwater flow.	Moderately difficult; poor aesthetics	High	Eliminated
		Asphalt cap	Potentially susceptible to cracks. Adverse affect on surface water and groundwater flow.	Difficult; poor aesthetics	High	Eliminated
		Multi-layer, multi-media cap	Effective and reliable. Adverse affect on surface water and groundwater flow.	Difficult	High	Eliminated

Table 2-2 (continued)

Secondary Screening of Technologies and Process Options for Soil at OU2

Soil General Response Actions	Remedial Technology Types	Process Options	Effectiveness	Implementability	Cost	Screening Comments
Containment (continued)	Cover	Soil cover	Effective and reliable. Erosion minimized and durability increased with vegetative cover.	Moderate	Moderate	Retained
Removal	Excavation	Solids excavation	Effective and reliable	Difficult, particularly with dewatering and surface water management, large volume	High	Retained
In Situ Treatment	Chemical Treatment	Solidification / stabilization	Effective and reliable	Moderate to difficult; requires vegetation clearing; ensure additive distribution/contact; potential poor aesthetics with limited opportunity for vegetative restoration.	High	Eliminated
	Biological Treatment	Phytoremediation	Potentially effective for uptake of select constituents of concern (COCs) within the root zone if the COC dissolved concentration is high enough, no effect outside root zone; not reliable if vegetation used as food source.	Moderate due to seasons	Relatively low capital, moderate to high cumulative O&M	Eliminated

Table 2-2 (continued)

Secondary Screening of Technologies and Process Options for Soil at OU2

Soil General Response Actions	Remedial Technology Types	Process Options	Effectiveness	Implementability	Cost	Screening Comments
Ex Situ Treatment	Chemical Treatment	Chemical extraction	Potentially effective and reliable if the proper acid/chelant is selected.	Difficult; requires clearing all vegetation and excavation of all ash material in soil; ensure additive distribution/contact; extractant and rinse liquids also require treatment/disposal.	One of the highest; requires excavation for treatment and replacement/disposal of treated ash material.	Eliminated
		Solidification / stabilization	Effective and reliable	Difficult; requires clearing all vegetation and excavation of all ash material in soil; ensure additive distribution/contact.	One of the highest; requires excavation for treatment and replacement/disposal of treated ash material.	Eliminated

Note(s):
**Shaded cells indicate that the remedial technology type and/or process option was eliminated from further evaluation.*
COCs – constituents of concern
O&M – operation and maintenance

2.3 Development of Alternatives

The four process options that were retained after the secondary screening step include no action, land use controls, soil cover, and removal. In Section 2.3.1, these process options are combined into remedial alternatives to address potential human health and ecological risks from ash material in soil at OU2 and to address the site-specific RAOs discussed in Section 1.3. The conceptual design of the various technology components of each identified remedial alternative is discussed in Section 2.3.2.

2.3.1 Identification of Alternatives

The no action alternative is required for baseline comparison; therefore, the first remedial alternative will be Alternative S-1: No Action. There is no active remediation, no monitoring, no land use controls, and no proposed change to existing conditions at the site under a no action alternative.

Land use controls by themselves do not address COC migration or potential ecological risk as necessary to achieve RAOs. However, land use controls in combination with a soil cover would achieve RAOs. The soil cover could be applied across the entirety of OU2 or only in targeted areas of OU2 to specifically address COC migration. Targeted areas for soil cover would include covering areas of currently exposed ash in soil, steep and/or unstable slopes, and the slopes in the vicinity of the ponds at the eastern end of OU2.

If OU2 was entirely covered with soil, then only institutional controls would be required to achieve RAOs. Institutional controls in the form of a UEC restricting future use of OU2 would need to be included as the ash material would be left in place. The other land use controls, such as perimeter patrols, signs, and/or fencing, would not be necessary to achieve RAOs with a full soil cover in place.

If OU2 was only partially covered with soil, then perimeter patrols or fencing and institutional controls would be required to achieve RAOs. While posted signs serve as a warning to potential trespassers and existing signs would be maintained, perimeter patrols or fencing are more reliable for discouraging trespassers. A targeted soil cover with institutional controls and either perimeter patrols or fencing would achieve RAOs. Given the concerns associated with appropriate fence location (i.e., top of shoreline slope versus bottom of shoreline slope), and the comparable effectiveness and reliability of perimeter patrols for discouraging trespassers, a targeted soil cover with perimeter patrols is a more easily implemented alternative.

A more detailed screening of the possible combinations of soil cover and land use controls would be required to determine the relative strengths and weaknesses of the tradeoff between extent of soil cover and land use control protection. Thus, two additional remedial alternatives include Alternative S-2: Targeted Soil Cover with Land Use Controls and Alternative S-3: Full Soil Cover with Institutional Controls. Both alternatives would require special design considerations for the banks of the ponds on the eastern end of OU2 where the water level could adversely impact the long-term stability of the soil cover. In addition, long-term monitoring would be required for both alternatives.

The remaining technology component for development of remedial alternatives is removal. Removal of ash material at OU2 would achieve RAOs; however, excavated ash material would have to be managed and the site restored. As no viable treatment process options were retained after screening, the excavated ash material would need to be transported off-site for disposal. The current landfill at the Indian River Power facility is designated for use by ongoing operations and is not only not available to accept excavated ash material from OU2, but does not have the capacity for the anticipated volume of ash material from OU2 which is estimated at approximately two million cubic yards. Removal of portions of OU2 would not achieve RAOs for OU2 because the soil is homogeneous with respect to COC distribution. There are no 'hotspots' to remove which would allow other less-impacted areas to be addressed by a less invasive remedial action. If removal is to be performed, it would be performed for the entire volume of ash material at OU2 including the immediate areas of the ponds at the eastern end of OU2. Thus, the final remedial alternative is Alternative S-4: Excavation and Off-site Disposal. The details of a site restoration plan associated with this alternative would be fine-tuned during remedial design; however, it would be anticipated to include, at a minimum, stabilization of the excavated area with vegetation and/or hardscape material to control potential sedimentation of surrounding tidal waters.

2.3.2 Description of Identified Alternatives

The conceptual designs of the components of the remedial alternatives are discussed in this section. The identified remedial alternatives are as follows:

- Alternative S-1: No Action
- Alternative S-2: Targeted Soil Cover with Land Use Controls
- Alternative S-3: Full Soil Cover with Institutional Controls
- Alternative S-4: Excavation and Off-site Disposal

2.3.2.1 Alternative S-1: No Action

The No Action alternative does not include any active remediation, treatment, containment, removal, land use controls, or monitoring. The existing conditions would not be altered except perhaps by ongoing natural processes. It should be noted that landside access to OU2 is controlled via 24-hour security guards, fence, and locked gates at the entrance to the plant; fencing around the facility; additional fencing and a locked gate at the entrance to the Site; and 'no trespassing private property' signs are posted sporadically on the perimeter of OU2.

2.3.2.2 Alternative S-2: Targeted Soil Cover with Land Use Controls

The Targeted Soil Cover with Land Use Controls alternative would consist of covering discrete areas in OU2 with a minimum of 12 inches of imported soil. Although a 6-inch depth would be sufficient to reduce the potential for exposure to ash material in soil for human and ecological receptors at this site, a soil cover thickness of 12 inches is the default requirement in the DNREC-SIRS policy for sites that will be used for commercial or industrial use (DNREC, 2010). The policy also requires the use of a marker fabric under the soil cover which will be included. The areas selected to be covered include those where potential for exposure to ash material in soil is greatest and totals approximately three acres. The proposed targeted soil cover areas include areas where exposed ash in soil has been documented and steeply sloped berms that may become unstable in the long-term located primarily along perimeter access roads and the banks of the two southern ponds. The proposed targeted soil cover areas are shown in **Figure 2-1**. The areas of documented exposed ash in soil, totaling approximately one acre, would be covered with soil and revegetated. The steep slopes of former berms in the interior of OU2, primarily located along the access roads, would be graded to more stable slopes, covered with soil, and revegetated. Many of these steeply sloped areas are currently vegetated. The banks of the two southern ponds on the eastern end of OU2 would be graded to more stable slopes, soil cover would be applied, and disturbed areas would be revegetated to minimize potential migration of ash material in soil in stormwater runoff into the ponds. In addition, the perimeter access road, which is proposed to be used for perimeter patrols (as described later in this section), would be covered with additional gravel or stone, as necessary, where the vegetative cover has not become established due to existing traffic. The remainder of OU2 with its existing vegetation, sand, and leaf-litter cover provides protection from exposure to human and non-digging ecological receptors, and minimizes potential migration of ash material in soil from wind or stormwater. In addition, the slopes immediately above the revetment along the shoreline were graded as part of the shoreline stabilization project and are already covered with six inches of imported topsoil and vegetated. Therefore, these slopes would not be reworked under this alternative. These covered and vegetated slopes account for approximately two and one half acres of OU2.

In order to apply the soil cover, existing vegetation would be cleared in targeted areas and the surface graded as necessary to achieve stable slopes. Existing vegetation would be chipped and spread on the OU2 surface in areas adjacent to and outside of the area of soil cover. Larger woody material such as large logs and tree stumps that cannot readily be chipped would be placed in areas adjacent to and outside of the area of soil cover. Appropriate best management practices (BMPs) would be utilized to control stormwater, erosion, sedimentation, and dust in construction areas. Temporary construction fence would be used as necessary to identify and protect work areas.

At 12 cubic yards per dump truck, upwards of 504 truckloads of unconsolidated soil would be required to import the soil needed for the cover. Additional truckloads of gravel would be required for the gravel on the perimeter access roads. Due to the high cost of topsoil, the minimum 12-inch compacted thickness of soil cover would be comprised of nine inches of clean soil fill topped with three inches of topsoil. A marker fabric would be applied to graded cover areas prior to placing soil cover. Native grass seed mix would be applied to the topsoil. Native species of tree saplings and shrubs would be installed in cover areas. Invasive vegetation management would be performed during the first five years of the re-vegetation effort in the targeted soil cover areas. Vegetation will be cleared from access roads on a regular basis to enable inspections of cover areas. The scope and method for planting and invasive vegetation management in covered areas would be defined in the remedial design and/or O&M plan.

The ponds on the eastern end of OU2 would not be filled or covered with soil. The banks of each pond would be graded to a stable slope and the soil cover would be applied to the banks down to the top elevation of the tidal zone. Erosion controls would be used as necessary during construction. Within the tidal zone elevation on the banks of each pond, the bank and edge of soil cover would be stabilized with planted vegetation.

Perimeter patrols would be conducted daily. Perimeter patrols would entail personnel driving to OU2 from the facility and traveling on the perimeter access road. Patrollers would visually inspect the shoreline for trespassers and signs of trespassers. Patrollers would verbally notify trespassers, if observed, of their violation and escort the trespassers off of the property. Patrollers would record information about the trespasser and the location of the incident for future reference. The need to address repeat trespassers or trespassing locations would be determined in subsequent periodic project reviews. If observations and records indicate that trespassing is not occurring, or occurring infrequently, the frequency of perimeter patrols may be reduced in the future.

The institutional controls would consist of a UEC limiting future land use at OU2. DNREC-SIRS notification would be required prior to any disturbance of OU2.

As the ash material would remain in place on-site untreated, long-term monitoring would be conducted to demonstrate continued achievement of the RAOs. Monitoring would include periodic visual inspection of the soil cover and other accessible areas of OU2 to ensure the soil cover is intact and no other areas of ash material are exposed. Any observed areas of disturbed soil cover would be repaired. Specific monitoring requirements would be evaluated in the Remedial Design and documented in the O&M Plan.

2.3.2.3 Alternative S-3: Full Soil Cover with Institutional Controls

The Full Soil Cover with Institutional Controls alternative would consist of covering the entirety of OU2 with a minimum of 12 inches of imported soil. Although a 6-inch depth would be sufficient to reduce the potential for exposure to ash material in soil for human and ecological receptors at this site, a soil cover thickness of 12 inches is the default requirement in the DNREC-SIRS policy for sites that will be used for commercial or industrial use (DNREC, 2010). The policy also requires the use of a marker fabric under the soil cover which will be included. The soil cover would extend to the top of the slope of the shoreline stabilization project. The slopes graded as part of the shoreline stabilization project are already covered with six inches of imported topsoil and vegetated. Therefore, these slopes would not be reworked under this alternative. These covered and vegetated slopes account for approximately two and one half acres of OU2 leaving approximately 91.1 acres of OU2 to be covered under this alternative.

In order to apply the soil cover, existing vegetation would be cleared from the entire surface of OU2 and the surface graded as necessary to achieve stable slopes. Cleared vegetation would be transported off-site for disposal. State sediment and stormwater management requirements for construction sites limit disturbed and unstabilized areas to less than 20 acres at a time. Therefore, vegetation clearing would have to be performed in phases. Appropriate BMPs would be utilized to control stormwater, erosion, sedimentation, and dust in construction areas. Temporary construction fence would be used as necessary to identify and protect work areas.

At 12 cubic yards per dump truck, upwards of 15,310 truckloads of unconsolidated soil would be required to import the soil needed for the cover. Due to the high cost of topsoil, the compacted 12-inch thickness of soil cover would be comprised of nine inches of clean soil fill topped with three inches of topsoil. A marker fabric would be applied to graded cover areas prior to placing soil cover. Native grass seed mix would be applied to the topsoil. Native species of tree saplings and shrubs would be installed in cover areas. Invasive vegetation management would be performed during the first five years of the re-vegetation effort in covered areas. Vegetation will be cleared from access roads on a regular basis to enable inspections of covered areas. The scope and method for planting and invasive vegetation management in covered areas would be defined in the remedial design and/or O&M plan.

The ponds on the eastern end of OU2 would not be filled or covered with soil. The banks of each pond would be graded to a stable slope and the soil cover would be applied to the banks down to the top elevation of the tidal zone. Erosion controls would be used as necessary during construction. Within the tidal zone elevation on the banks of each pond, the bank and edge of soil cover would be stabilized with planted vegetation.

The institutional controls would consist of a UEC limiting future land use at OU2. DNREC-SIRS notification would be required prior to any disturbance of OU2.

As the ash material would remain in place on-site untreated, long-term monitoring would be conducted to demonstrate continued achievement of the RAOs. Monitoring would include periodic visual inspection of the soil cover to ensure the soil cover is intact. Any observed areas of disturbed soil cover would be repaired. Specific monitoring requirements would be evaluated in the Remedial Design and documented in the O&M Plan.

2.3.2.4 Alternative S-4: Excavation and Off-site Disposal

The Excavation and Off-site Disposal alternative would consist of removal of nearly two million cubic yards of ash material from OU2 to the depth of native soil. The volume estimation is provided in Section 1.4. The volume includes sediment in ponds on the eastern end of OU2. State sediment and stormwater management requirements for construction sites limit disturbed and unstabilized areas to less than 20 acres at a time. Therefore, vegetation clearing and removal would have to be performed in phases to address the approximately 93.6 acres of OU2. Excavation would be performed with traditional earth-moving equipment such as excavators and loaders. Temporary construction fence would be used as necessary to identify and protect work areas. At 12 cubic yards per dump truck, upwards of 198,251 truckloads of unconsolidated soil would be required to haul the ash material. Additional trucks would be required for transporting removed vegetation. As the facility currently uses a railroad for delivery of coal, the potential for also utilizing the railroad for transport of ash material off-site could be evaluated in the remedial design.

Excavated ash material would need to be characterized for waste disposal prior to acceptance by and transport to an off-site facility. Waste characterization is typically performed by analyzing samples collected from stockpiles of waste material at a designated frequency per volume. A temporary soil management area would be established on OU2 for handling freshly excavated ash material, stockpiling ash material pending acceptance, and loading for transport off-site. Towards the end of removal of OU2, the temporary soil management area would have to be relocated elsewhere on the property. During remedial design when likely disposal facilities are identified, the potential for *in situ* characterization and direct loading for transport off-site can be evaluated.

Measures for stormwater management would be implemented in and around the excavation areas. These measures would minimize contact of precipitation with ash material, treat stormwater as necessary, and control stormwater flows from damaging work areas. As the excavation nears the elevation of the groundwater table, excavated ash material dewatering systems would be established and groundwater infiltration into excavation areas would be managed. As the excavation nears the elevation of the tidal zone, additional measures to control and manage the infiltration of the surrounding surface waters would also be implemented. State approval of a sediment and stormwater management plan and coverage under National Pollutant Discharge Elimination System (NPDES) for construction site activities would be required to perform this work. The stone revetment installed in OU1 for shoreline stabilization would not function properly with OU2 soil removed behind it. The stone revetment was designed and constructed as a slope protection and not as a stand-alone barrier. Therefore, the stone of the stone revetment would either be used to stabilize the excavation area, removed from the site, or reused during site restoration. Removal of the stone revetment would result in significant disturbance of the shoreline and OU1.

In order to meet the requirements for project phasing and stabilization in the State-approved sediment and stormwater management plan (e.g., no more than 20 acres disturbed at any one time), the excavation areas would need to be restored in phases. For the purposes of the analysis in this FS, a basic vegetative restoration consisting of importing limited backfill to create a mound above the tidal elevation and application of a native grass seed mix is assumed. Native species of tree saplings and shrubs would be installed. Invasive vegetation management would be performed during the first five years of the re-vegetation effort in covered areas. Vegetation will be cleared from access roads on a regular basis to enable inspections. The scope and method for planting and invasive vegetation management in covered areas would be defined in the remedial design and/or O&M plan. As the ash material of OU2 would be removed, long-term monitoring is not a component of this alternative. Visual inspection of the restored area would be performed through the first few growing seasons only to ensure vegetation becomes established.

2.4 Screening of Alternatives

The criteria used to screen the four remedial alternatives are similar to those used in the secondary screening of process options and include the following:

- Effectiveness in meeting RAOs;
- Appropriate engineering practices based on applicability, feasibility for the site, and reliability; and
- Relative cost.

As only a limited number of process options were retained after the screening, resulting in a limited number of alternatives, and because the screening criteria are similar to those already used, this initial screening step for alternatives is not necessary. The detailed analysis of the remedial alternatives is provided in the following sections.

3.0 Detailed Analysis of Alternatives

The objective of the detailed analysis of remedial alternatives is to present the relative advantages and disadvantages of different contaminant management approaches for OU2. This is accomplished by evaluating the alternatives against the criteria that DNREC will use to make the selection of the preferred alternative.

The evaluation of alternatives is provided as a two-step process. First, the alternatives are individually evaluated against the criteria as presented in this section. Second, the alternatives are evaluated in relation to each other for each criterion (Section 4.0). The relative strengths and weaknesses of each alternative on a qualitative and quantitative basis are highlighted during this process. The degree to which uncertainty about site conditions and the alternatives may influence the evaluation process are also identified.

3.1 Definition of Evaluation Criteria

As per Table 5-4 of the *Delaware HSCA Guidance* (DNREC, 1994), and as revised in Sections 12.4.4 and 12.4.5 of the *Regulations Governing Hazardous Substance Cleanup* effective August 11, 2012 (DNREC, 2012), the aspects of each criteria that should be considered during alternative evaluation are defined in **Table 3-1**. At a minimum, an approved remedial action shall meet the initial threshold criteria. The balancing criteria will then be considered in selecting a preferred remedial action from the alternatives meeting the initial threshold criteria. For remedial action alternatives that satisfy the initial threshold criteria and after considering the balancing criteria, preference shall be given to the remedial action which is most cost effective.

Table 3-1

Criteria for Detailed Analysis of Alternatives

CRITERIA	CONSIDERATIONS
Threshold Criteria	
Overall Protection of Public Health, Welfare, and the Environment	Attains compliance cleanup levels; and conditional cleanup levels.
Compliance with Applicable Laws and Regulations	Federal, state, and local; chemical-specific; action-specific; location specific; and other guidance.
Balancing Criteria	
Community Acceptance	Desired use of property after remediation; historical issues related to site; and public concerns about remediation.
Compliance Monitoring Requirements	Requirements for compliance monitoring; ability to monitor success of remediation; exposure pathways that cannot be monitored; and consequences of failed remedy.

CRITERIA	CONSIDERATIONS
Technical Practicability	Likelihood that technologies will meet performance specifications; ability to construct and implement technology; reliability of technology; ease of undertaking additional remedial actions if needed; availability of services; availability of equipment and specialists; and availability of technologies.
Restoration Time Frame	Time until principal threats are addressed; time until secondary threats are addressed; and time until remedial action objectives are met.
Reduction of Toxicity, Mobility, and Volume of Contamination	Mitigation of principal risks at site; special requirements for treatment process; and extent toxicity, mobility, and volume reduced.
Long-term Effectiveness	Contamination remaining on-site and associated risk; treatment residuals and associated risk; type and degree of long-term management; difficulties associated with long-term management; and potential for alternative failure and associated risks.
Short-term Effectiveness	Protection of community during implementation; protection of workers during implementation; environmental impacts expected during implementation; and available mitigation measures.
Cost	Capital and operation and maintenance costs.

Another factor in the evaluation of alternatives involves the revised ecological risk assessment discussed in Section 1.2.5.2 and presented in **Appendix B**. That evaluation demonstrated the effect of several of the more conservative assumptions on the terrestrial food web model and resulting over-estimation of ecological risk for the Site presented in the RI. The evaluation re-estimated the potential ecological risks by using more realistic input parameters. The results of the revised terrestrial food web model indicate that under current site conditions, ecological hazards at OU2 may already be at acceptable levels and remedial actions may not be necessary in order to ensure the protection of ecological receptors at OU2.

3.2 Individual Analysis of Alternatives

In this section, the remedial alternatives for OU2 are evaluated against the criteria presented in Section 3.1. The components of each alternative were described in Section 2.3.2. The individual alternatives and evaluation criteria are summarized in **Table 3-2** at the end of this section. The alternatives being evaluated include the following:

- Alternative S-1: No Action
- Alternative S-2: Targeted Soil Cover with Land Use Controls
- Alternative S-3: Full Soil Cover with Institutional Controls

- Alternative S-4: Excavation and Off Site Disposal

3.2.1 Alternative S-1: No Action

As noted in Section 2.3.2.1, the No Action alternative does not include any active remediation, treatment, containment, removal, land use controls, or monitoring. The existing conditions would not be altered except perhaps by ongoing natural processes. It should be noted that landside access to OU2 is controlled via 24-hour security guards, fence, and locked gates at the entrance to the plant; fencing around the facility; additional fencing and a locked gate at the entrance to the Site; and ‘no trespassing private property’ signs are posted sporadically on the perimeter of OU2.

3.2.1.1 Overall protection of public health, welfare, and the environment

The No Action alternative would not reduce or minimize the potential short-term or long-term risks to humans or ecological receptors from exposure to ash material at OU2. The assessment of pre- and post-remediation human health risks are presented in **Appendix C**. This alternative does not minimize the potential migration of COCs from OU2. There are no adverse impacts to natural resources resulting from this remedial action.

3.2.1.2 Compliance with applicable laws and regulations

Applicable requirements for the No Action alternative are limited to the chemical-specific requirements listed in **Table 1-2**. The No Action alternative would not comply with state regulations as ash material would remain exposed at OU2. Location-specific requirements listed in **Table 1-3** and action-specific requirements listed in **Table 1-4** are not applicable for the No Action alternative.

3.2.1.3 Community acceptance

This alternative has not yet been formally presented to the public for comment. There is a minimum 20 day public comment period from the date of issuance of the public notice for the Proposed Plan. Responses to the public’s comments will be prepared prior to the selection of the remedial action.

3.2.1.4 Compliance monitoring requirements

Monitoring is not a component of the No Action alternative and, therefore, there is no opportunity to monitor changing conditions. As there is no action being performed under this alternative, there is no opportunity for failure of a remedy.

3.2.1.5 Technical practicability

The No Action alternative does not involve remedial action and, therefore, technical practicability is not a consideration. No services, equipment, or materials are necessary to implement this alternative. This alternative would not interfere with the implementation of any potential future remedial actions.

3.2.1.6 Restoration time frame

The No Action alternative does not involve remedial action and, thus, potential risks are not addressed at any time. RAOs would not be achieved under the No Action alternative. Thus, the restoration time frame is indefinite, potentially infinite, and not applicable for this alternative.

3.2.1.7 Reduction of toxicity, mobility, and volume of contamination

The No Action alternative would not involve active treatment, containment, removal, or disposal of ash material at OU2. Due to their recalcitrant nature, the COCs are not likely to naturally attenuate. Therefore, there would be no reduction in toxicity, mobility, or volume of COCs. In the absence of active treatment and degradation processes, the current potential risks to human health and the environment would not change. The potential migration of COCs through surface water run-off and dust would not be addressed.

3.2.1.8 Long-term effectiveness

Ash material would remain in place at OU2 under the No Action alternative. The current potential risks to human health and the environment would not change. The No Action alternative does not involve active treatment and would not yield treatment residuals. Long-term management is not a component of the No Action alternative. Monitoring data would not be obtained to assess potential changes in future conditions. The potential effects of a 1.5 meter sea level rise on OU2 would not be identified or mitigated. As there is no action being performed under this alternative, there is no opportunity for failure of a remedy.

3.2.1.9 Short-term effectiveness

Because this remedy does not involve remedial action, there would not be any new contribution to potential human health or environmental risk during implementation. No adverse environmental impacts such as sedimentation or vegetative damage would be incurred during implementation of the No Action alternative. No energy expended and no carbon footprint for implementation of this alternative.

3.2.1.10 Cost

There are no capital or O&M costs associated with implementation of the No Action alternative.

3.2.2 Alternative S-2: Targeted Soil Cover with Land Use Controls

As detailed in Section 2.3.2.2, the Targeted Soil Cover with Land Use Controls alternative includes clearing discrete areas of vegetation, grading and placing soil cover over discrete areas of currently exposed ash material in soil and unstable slopes in OU2, performing perimeter patrols, maintaining ‘no trespassing private property’ signs, establishing a UEC to limit future land use, and long-term monitoring.

3.2.2.1 Overall protection of public health, welfare, and the environment

The Targeted Soil Cover with Land Use Controls alternative would limit potential exposure of humans and ecological receptors to ash material in soil at OU2 thereby minimizing potential risk. The assessment of pre- and post-remediation human health risks are presented in **Appendix C**. This alternative would minimize the potential migration of COCs from OU2 by controlling ash material in soil currently exposed and areas most likely to potentially become exposed (i.e., steep slopes) to wind and stormwater. Adverse impacts to natural resources resulting from this remedial action would be limited to specific areas of cleared vegetation at OU2 and would be temporary in nature.

3.2.2.2 Compliance with applicable laws and regulations

Applicable requirements for the Targeted Soil Cover with Land Use Controls alternative include those listed in **Tables 1-2, 1-3, and 1-4** with the exception of the Delaware Regulations Governing Solid Waste (listed under action-specific requirements in **Table 1-4**). The Targeted Soil Cover with Land Use Controls alternative would comply with state regulations as ash material in soil would be covered to limit potential exposure and land use controls would restrict access to OU2. State and federal permits for construction activities could be easily obtained as total project disturbance is limited in size and would occur only in uplands.

3.2.2.3 Community acceptance

This alternative has not yet been formally presented to the public for comment. There is a minimum 20 day public comment period from the date of issuance of the public notice for the Proposed Plan. Responses to the public's comments will be prepared prior to the selection of the remedial action.

3.2.2.4 Compliance monitoring requirements

Short-term monitoring would be conducted to ensure vegetation placed for soil stabilization becomes established and invasive vegetation does not. Long-term monitoring would be conducted to demonstrate continued achievement of the RAOs. Any observed areas of disturbed soil cover would be repaired. Success of the remedy can be monitored through visual inspection of surface conditions. Potential exposure pathways for ash material can be adequately monitored through visual inspection of surface conditions. Areas that are repeatedly in need of maintenance, if any, may indicate localized failure of the remedy and alternate means of limiting exposure to ash material would be considered.

3.2.2.5 Technical practicability

Numerous qualified vendors and contractors and sufficient local materials are available to implement this remedy, including the tasks of vegetation clearing and earth moving. The soil cover and perimeter patrols are reliable measures for minimizing occurrence of trespassers and potential exposure to ash material in soil. Qualified legal support for development of the UEC is readily available. Implementation of this alternative would not interfere with potential additional future remedial action, if necessary, to address changing conditions at OU2.

3.2.2.6 Restoration time frame

Implementation of the remedy is anticipated to be completed in less than one year from the start of construction. The potential for exposure to and migration of ash material in soil would be minimized as soon as the soil cover is in place. The potential for exposure to ash material in soil would be further limited when perimeter patrols are performed and the UEC is established. RAOs would be achieved upon completion of construction.

3.2.2.7 Reduction of toxicity, mobility, and volume of contamination

The Targeted Soil Cover with Land Use Controls alternative would not involve active treatment, removal, or disposal of ash material at OU2. Due to their recalcitrant nature, the COCs are not likely to naturally attenuate. Therefore, there would be no reduction in toxicity or volume of COCs at OU2. However, the potential exposure routes would be limited by application of soil cover, performance of perimeter patrols to exclude trespassers, and enforcement of the UEC. The potential migration of ash material in soil through surface water run-off and dust and, thus, the mobility of the COCs, would be minimized by the application of soil cover. Limited process residuals including decontamination fluids (i.e., from earth moving equipment cleaning) and PPE would require management and disposal during remedy implementation.

3.2.2.8 Long-term effectiveness

Ash material would remain in place at OU2 under the Targeted Soil Cover with Land Use Controls alternative. The current potential risks to human health and the environment would be managed by long-term maintenance of the soil cover, performance of perimeter patrols, and enforcement of the UEC. The Targeted Soil Cover with Land Use Controls alternative does not involve active treatment and would not yield treatment residuals. Limited vegetation management effort (i.e., clearing access routes of growing vegetation) may be required in order to perform inspections and maintenance of soil cover over time. Areas of OU2 that are repeatedly in need of maintenance, if any, may indicate localized failure of the remedy, and alternate means of limiting exposure to ash material in soil would be considered. The potential effects of a 1.5 meter sea level rise by the year 2100 on OU2 under the Targeted Soil Cover with Land Use Controls alternative would be identified during long-term monitoring and can be addressed as necessary. This alternative does not include components to specifically address potential adverse effects of sea level rise in the next century such as increased shoreline erosion and elevated water table.

3.2.2.9 Short-term effectiveness

During implementation of the Targeted Soil Cover with Land Use Controls alternative, new contributions to potential human health risk include exposure of construction workers to ash material during vegetation clearing and grading, physical safety of the community and construction workers during transport and placement of clean fill (i.e., increased traffic), physical safety of construction workers during heavy equipment operation, and exposure to dust from disturbed areas of OU2. Proper training, appropriate PPE, and consistency with the project site-specific health and safety plan would protect construction workers. Enforcing and obeying DOT standards and posted speed limits for trucking would reduce the potential for incidents in the community and at the site. Dust controls would be implemented in disturbed areas during construction. Specific controls for dust and air monitoring as necessary to protect construction workers will be identified in the remedial design document.

The environment would face minor potential adverse impacts due to construction activities such as sedimentation and/or vegetative damage. Vegetation would only be cleared to allow access to and placement of the soil cover. BMPs for erosion and sedimentation control would be used to minimize potential impacts to the environment. Wildlife would be able to avoid the small areas of construction.

3.2.2.10 Cost

The estimated capital and O&M costs associated with the Targeted Soil Cover with Land Use Controls alternative are detailed in **Appendix D**. The total capital cost is estimated to be approximately $1.1 million. The present value (presented in 2012 dollars using a rate of 2%) of 30 years of O&M is estimated to be approximately $0.9 million. The total present worth cost (presented in 2012 dollars using a rate of 2% with 30 years of O&M) of the Targeted Soil Cover with Land Use Controls alternative is estimated to be approximately $2.1 million.

3.2.3 Alternative S-3: Full Soil Cover with Institutional Controls

As detailed in Section 2.3.2.3, the Full Soil Cover with Institutional Controls alternative includes clearing vegetation from the entire surface of OU2, grading and placing soil over the entire surface of OU2, maintaining 'no trespassing private property' signs, establishing a UEC to limit future land use, and long-term monitoring.

3.2.3.1 Overall protection of public health, welfare, and the environment

The Full Soil Cover with Institutional Controls alternative would limit exposure of humans and ecological receptors to ash material in soil at OU2 thereby minimizing potential risk. The assessment of pre- and post-remediation human health risks are presented in **Appendix C**. This alternative would minimize the potential migration of COCs from OU2 by controlling ash material in soil from wind and stormwater forces. Adverse impacts to natural resources resulting from this remedial action would be significant at OU2 in terms of habitat and vegetation destruction; however, they would be temporary in nature.

3.2.3.2 Compliance with applicable laws and regulations

Applicable requirements for the Full Soil Cover with Institutional Controls alternative include those listed in **Tables 1-2, 1-3** and **1-4** with the exception of the Delaware Regulations Governing Solid Waste (listed under action-specific requirements in **Table 1-4**). The Full Soil Cover with Institutional Controls alternative would comply with state regulations as ash material in soil would be covered to limit potential exposure and Institutional Controls would restrict future land use. State and federal permits for construction activities could be obtained; however, effort would be required to address total destruction of existing vegetation, habitat, and wildlife. Although no State and federally-listed threatened and endangered species are known to be on site, based on previous correspondence with state and federal agencies and field surveys, the impact or potential impact of the project on the existing environment would be a significant consideration in issuance of permits.

3.2.3.3 Community acceptance

This alternative has not yet been formally presented to the public for comment. There is a minimum 20 day public comment period from the date of issuance of the public notice for the Proposed Plan. Responses to the public's comments would be prepared prior to the selection of the remedial action.

3.2.3.4 Compliance monitoring requirements

Short-term monitoring would be conducted to ensure vegetation placed for soil stabilization becomes established and invasive vegetation does not. Long-term monitoring would be conducted to demonstrate continued achievement of the RAOs. Any observed areas of disturbed soil cover would be repaired. Success of the remedy can be monitored through visual inspection of surface conditions. Potential exposure pathways for ash material can be adequately monitored through visual inspection of surface conditions. Areas that are repeatedly in need of maintenance, if any, may indicate localized failure of the remedy, and alternate means of limiting exposure to ash material would be considered.

3.2.3.5 Technical practicability

Numerous qualified vendors and contractors are available to implement this remedy including the tasks of vegetation clearing and earth moving. Due to the large volume of clean fill required to cover OU2, soil may need to be sourced from multiple locations which increases the complexity of implementation. The soil cover is a reliable measure for minimizing potential exposure to ash material in soil. Qualified legal support for development of the UEC is readily available. Implementation of this alternative would not interfere with potential additional future remedial actions, if necessary, to address changing conditions at OU2.

3.2.3.6 Restoration time frame

Implementation of the remedy is anticipated to be completed in approximately three years from the start of construction. The time frame could be reduced by increasing the number of construction crews and pieces of construction equipment. The potential for exposure to and migration of ash material in soil would be minimized as soon as the soil cover is in place. The potential for exposure to ash material in soil would be further limited by establishment of the UEC. RAOs would be achieved upon completion of construction.

3.2.3.7 Reduction of toxicity, mobility, and volume of contamination

The Full Soil Cover with Institutional Controls alternative would not involve active treatment, removal, or disposal of ash material at OU2. Due to their recalcitrant nature, the COCs are not likely to naturally attenuate. Therefore, there would be no reduction in toxicity, mobility, or volume of COCs at OU2. However, the potential exposure routes would be limited by application of soil cover and enforcement of the UEC. The potential migration of the COCs through surface water run-off and dust would be minimized by the application of soil cover. Process residuals including decontamination fluids (i.e., from earth moving equipment cleaning) and PPE would require management and disposal during remedy implementation.

3.2.3.8 Long-term effectiveness

Ash material would remain in place at OU2 under the Full Soil Cover with Institutional Controls alternative. The current potential risks to human health and the environment would be managed by long-term maintenance of the soil cover and enforcement of the UEC. The Full Soil Cover with Institutional Controls alternative does not involve active treatment and would not yield treatment residuals. Vegetation management efforts (i.e., clearing access routes of growing vegetation) may be required in order to perform inspections and maintenance, if any, of soil cover over time. Areas of OU2 that are repeatedly in need of maintenance may indicate localized failure of the remedy and alternate means of limiting exposure to ash material would be considered. The potential effects of a 1.5 meter sea level rise by the year 2100 on OU2 under the Full Soil Cover with Institutional Controls alternative would be identified during long-term monitoring and can be addressed as necessary. This alternative does not include components to specifically address potential adverse effects of sea level rise in the next century such as increased shoreline erosion and elevated water table.

3.2.3.9 Short-term effectiveness

During implementation of the Full Soil Cover with Institutional Controls alternative, new contributions to potential human health risk include exposure of construction workers to ash material during vegetation clearing and grading, physical safety of the community and construction workers during transport and placement of clean fill (i.e., increased traffic), physical safety of construction workers during heavy equipment operation, and exposure to dust from disturbed areas of OU2. Proper training, appropriate PPE, and consistency with the project site-specific health and safety plan would protect construction workers. Enforcing and obeying DOT standards and posted speed limits for trucking would reduce the potential for incidents in the community and at the site. Dust controls would be implemented in disturbed areas during construction. Specific controls for dust and air monitoring as necessary to protect construction workers will be identified in the remedial design document.

The environment would face major potential adverse impacts due to construction activities such as sedimentation and the complete deforestation of OU2. The entirety of the existing vegetation, habitat, and wildlife on OU2 would likely be destroyed although larger terrestrial species may successfully flee. BMPs for erosion and sedimentation control would be used to minimize potential impacts to the environment.

3.2.3.10 Cost

The capital and O&M costs associated with the Full Soil Cover with Institutional Controls alternative are detailed in **Appendix D**. The total capital cost is estimated to be approximately $13.6 million, and as the remedy would be implemented over three years, the present value (presented in 2012 dollars using a rate of 2%) of the capital cost is estimated to be approximately $13.1 million. The present value (presented in 2012 dollars using a rate of 2%) of 30 years of O&M after the remedy is implemented is estimated to be approximately $3.3 million. The total present worth cost (presented in 2012 dollars using a rate of 2% and 30 years of O&M) of the Full Soil Cover with Institutional Controls alternative is estimated to be approximately $16.4 million.

3.2.4 Alternative S-4: Excavation and Off-Site Disposal

As detailed in Section 2.3.2.4, the Excavation and Off-Site Disposal option includes clearing vegetation from the entire surface of OU2, excavating ash material at OU2, removing the stone revetment in OU1, excavation, soil dewatering, temporarily storing stockpiles on-site for waste characterization, transport and disposal of excavated material at a permitted facility, and restoring excavated areas.

3.2.4.1 Overall protection of public health, welfare, and the environment

The Excavation and Off-site Disposal alternative would significantly reduce potential exposure of humans and ecological receptors to ash material at OU2 thereby minimizing potential risk at the site. The assessment of pre- and post-remediation human health risks are presented in **Appendix C**. Risk is transferred off-site with the excavated material. This alternative would minimize the potential migration of COCs from OU2 by removing ash material. Adverse impacts to natural resources resulting from this remedial action would be significant at OU2 in terms of habitat and vegetation destruction.

3.2.4.2 Compliance with applicable laws and regulations

Applicable requirements for the Excavation and Off-site Disposal alternative include those listed in **Tables 1-2, 1-3** and **1-4** with the exception of the Delaware Uniform Environmental Covenants Act (UECA; listed under action-specific requirements in **Table 1-4**). The ash material would be entirely removed under this alternative so no environmental covenants would be necessary. State and federal permits for construction activities may be difficult to obtain due to the extent of terrain alteration under this alternative. Significant effort would be required to address total vegetation, habitat, and wildlife destruction and significant wetlands impacts particularly in the necessary reconstruction of OU1. Wetland mitigation would be required for any impacts to federally- or State-regulated wetlands adjacent to OU2. Although no State and federally-listed threatened and endangered species are known to be on site, based on previous correspondence with state and federal agencies and field surveys, the impact or potential impact of the project on the existing environment would be a significant consideration in issuance of permits. Stormwater controls, stormwater treatment, and surface water and groundwater infiltration management would need to be designed and permitted. Approval for site restoration design and construction would require coordination with multiple state and federal regulatory authorities.

3.2.4.3 Community acceptance

This alternative has not yet been formally presented to the public for comment. There is a minimum 20 day public comment period from the date of issuance of the public notice for the Proposed Plan. Responses to the public's comments would be prepared prior to the selection of the remedial action.

3.2.4.4 Compliance monitoring requirements

Monitoring of the restoration area would be conducted in the first five years after restoration to ensure vegetation becomes established for soil stabilization and that stormwater runoff is controlled. There are no longer-term monitoring requirements for this alternative.

3.2.4.5 Technical practicability

Excavation and off-site disposal is a common remedy using readily available contractors and equipment. However, because of the large volume of material to be excavated at OU2, the shallow groundwater, the proximity of OU2 to surface waters, and the limited access for high volume trucking through the active facility, this alternative would be difficult to implement at this site. Excavated materials would have to be dewatered prior to transport. Dewatering liquids and other excavation infiltration waters would have to be managed including controlling where they flow, containment, treatment, discharge, and disposal. Excavation near tidal waters below the elevation of the tidal zone would require specialized expertise for engineering design and implementation. The stone revetment installed for the remedy of OU1 would be removed or significantly altered as part of the OU2 soil removal. In addition, the large volume of material to be disposed of may require contracting with multiple permitted facilities which increases the complexity of implementation. The technology is reliable for removing soil. Under this alternative, no potential future remedial actions are anticipated to be necessary to address changing conditions.

3.2.4.6 Restoration time frame

Implementation of the remedy is anticipated to be completed in approximately 23 years from the start of excavation. The time frame could be reduced by increasing the number of construction crews and pieces of construction equipment. The potential for exposure to and migration of ash material would be minimized as soon as the ash material is removed and disposed of off-site but will take many years to achieve. RAOs would be achieved upon completion of excavation and restoration area construction.

3.2.4.7 Reduction of toxicity, mobility, and volume of contamination

The Excavation and Off-site Disposal alternative permanently reduces the toxicity, mobility, and volume of COCs at OU2 by transferring ash material to a permitted facility located off-site. At the permitted off-site disposal facility, the ash material would remain untreated and there would be no reduction in toxicity or volume. However, the long-term mobility of the COCs would be minimized through containment of the impacted media. The total volume of ash material to be excavated from OU2 and disposed of off-site is identified in Section 1.4. The restored OU2 would not pose any human health or ecological risks.

Process residuals may include wash water from equipment decontamination, accumulated stormwater, water from soil dewatering, and disposable PPE. These residuals would require management including treatment and/or disposal.

3.2.4.8 Long-term effectiveness

The Excavation and Off-site Disposal alternative is effective in removing ash material and the presumed source of COCs to minimize potential risk at the restored OU2. The excavated material would be managed at a permitted facility so there is no long-term management required for OU2. Process residuals would be managed during implementation of this alternative (i.e., short-term). The potential effects of a 1.5 meter sea level rise by the year 2100 on the restored OU2 under the Excavation and Off-site Disposal alternative are not specifically addressed by any component of the remedy. The surface elevation of the restored OU2 would be significantly lower than it is now which makes it more vulnerable to damage by the potential effects of sea level rise in the next century. Failure of the restoration, due to sea level rise or otherwise, may result in sedimentation of surrounding surface waters from clean fill used in restoration.

3.2.4.9 Short-term effectiveness

During implementation of the Excavation and Off-site Disposal alternative, new contributions to potential human health risk include exposure of construction workers to ash material during vegetation clearing and excavation, physical safety of the community and construction workers during transport and placement of excavated material and clean fill (i.e., increased traffic), physical safety of construction workers during heavy equipment operation, and exposure to dust from disturbed areas of OU2. Proper training, appropriate PPE, and consistency with the project site-specific health and safety plan would protect construction workers. Enforcing and obeying DOT standards and posted speed limits for trucking would reduce the potential for incidents in the community and at the site. Dust controls would be implemented in disturbed areas during construction. Specific controls for dust and air monitoring as necessary to protect construction workers will be identified in the remedial design document.

Until remediation goals are met (i.e., 23 years of implementation), there exists a potential risk to the child trespassing fisherman through ingestion, inhalation, and contact with ash material. The use and maintenance of temporary construction fencing during remediation would minimize the short-term risk to the trespassing fisherman receptor.

The environment would face major adverse impacts due to construction activities such as total vegetative and habitat destruction and significant potential for sedimentation. The entirety of the existing vegetation, habitat, and wildlife on OU2, including the ponds and adjacent OU1, would be destroyed although larger terrestrial species may successfully flee. BMPs for erosion and sedimentation control would be used to minimize potential impacts to the environment.

3.2.4.10 Cost

The capital and O&M costs associated with the Excavation and Off-site Disposal alternative are detailed in **Appendix D**. The total capital cost is estimated to be approximately $361.9 million, and as the remedy would be implemented over 23 years, the estimated present value (presented in 2012 dollars using a rate of 2%) of the capital cost is approximately $287.8 million. The present value (presented in 2012 dollars using a rate of 2%) of 5 years of O&M after the remedy is implemented is estimated to be approximately $1.7 million. The total present worth cost (presented in 2012 dollars using a rate of 2% with five years of O&M) of the Excavation and Off-site Disposal alternative is estimated to be approximately $289.6 million.

Table 3-2

Summary of Individual Analysis of Alternatives

ALTERNATIVE / CRITERIA	S-1 No Action	S-2 Targeted Soil Cover with Land Use Controls	S-3 Full Soil Cover with Institutional Controls	S-4 Excavation and Off-site Disposal
Threshold Criteria				
Protective of Public Health, Welfare, and the Environment	No	Yes	Yes	Yes
Complies with Applicable Laws and Regulations	No	Yes	Yes, with wildlife review	Yes, with wildlife review and wetland mitigation
Balancing Criteria				
Community Acceptance	TBD	TBD	TBD	TBD
Monitoring	None performed	Required short- and long-term	Required short- and long-term over entire site	Required short-term
Technically Practicable	Yes	Yes	Yes with sufficient materials	Yes with specialized design
Restoration Time Frame (time to achieve RAOs)	NA	< 1 year	3 years	23 years
Reduces Toxicity, Mobility, and Volume of Contamination	No	Yes, mobility	Yes, mobility	Yes (on site)
Effective over the Long-term	No	Yes with monitoring	Yes with monitoring	Yes
Effective over the Short-term	Unacceptable	Acceptable, limited environmental impact	Acceptable, significant environmental impact	Acceptable with management, significant environmental impact
Cost				
Capital (PW)	$0	$1,110,272	$13,071,456	$287,832,490
O&M (PW)	$0	$946,119 (30 yr)	$3,316,193 (30 yr)	$1,730,972 (5 yr)
Total (PW)	$0	$2,056,391	$16,387,649	$289,563,462

Notes:
NA – not applicable
TBD – to be determined
O&M – Operations and Maintenance
PW – Present Worth (in 2012 dollars using rate of 2%)

4.0 Comparative Analysis of Alternatives

In this section, the four remedial alternatives for OU2, that were described and analyzed in detail in previous sections, are evaluated in relation to one another. For each criterion, the alternatives are described in order of decreasing preference. The comparison of alternatives and evaluation criteria are summarized in **Table 4-1** at the end of this section. A more detailed comparison of alternatives and scoring of alternatives is presented in **Appendix E**.

4.1 Overall protection of public health, welfare, and the environment

The Excavation and Off-site Disposal alternative offers the highest degree of risk reduction for potential exposure of humans and ecological receptors to ash material at OU2 with the greatest potential for adverse environmental impacts. The Targeted Soil Cover with Land Use Controls and Full Soil Cover with Institutional Controls alternatives would limit potential exposure of humans and ecological receptors to ash material in soil at OU2 thereby minimizing potential risk. The No Action alternative would not reduce or minimize the potential short-term or long-term risks to humans or ecological receptors from exposure to ash material at OU2.

The Excavation and Off-site Disposal alternative would minimize the potential migration of COCs from OU2 by removing ash material. The Full Soil Cover with Institutional Controls and Targeted Soil Cover with Land Use Controls alternatives would minimize the potential migration of COCs from OU2 soil. The No Action alternative does not minimize the potential migration of COCs from OU2.

There are no adverse impacts to natural resources resulting from the No Action alternative. Adverse impacts to natural resources resulting from the Targeted Soil Cover with Land Use Controls alternative would be limited to specific areas of cleared vegetation at OU2 and would be temporary in nature. Adverse impacts to natural resources resulting from the Full Soil Cover with Institutional Controls and Excavation and Off-site Disposal alternatives would be significant at OU2 in terms of habitat and vegetation destruction; however, the adverse impacts would also include immediate surrounding areas (i.e., OU1 and adjacent wetlands) under the Excavation and Off-site Disposal alternative.

4.2 Compliance with applicable laws and regulations

The Targeted Soil Cover with Land Use Controls alternative would comply with state regulations and permit requirements. The Full Soil Cover with Institutional Controls alternative would comply with state regulations but mitigation for environmental impacts during implementation may be required. The Excavation and Off-site Disposal alternative would comply with state regulations but mitigation for significant environmental impacts during implementation would likely be required. The No Action alternative would not comply with state regulations as ash material would remain exposed at OU2.

4.3 Community acceptance

The alternatives have not yet been formally presented to the public for comment. There is a minimum 20 day public comment period from the date of issuance of the public notice for the Proposed Plan. Responses to the public's comments will be prepared prior to the selection of the remedial action.

4.4 Compliance monitoring requirements

Short-term monitoring to ensure vegetation establishment for site stabilization is required for each of the three remedial alternatives involving site disturbance. Long-term monitoring is not required for the Excavation and Off-site Disposal alternative. Long-term monitoring would be required for both the Targeted Soil Cover with Land Use Controls and Full Soil Cover with Institutional Controls alternatives to ensure cover integrity is maintained and to demonstrate continued achievement of the RAOs. Although the Full Soil Cover with Institutional Controls alternative would require visual inspection of a larger area of soil cover than under the Targeted Soil Cover with Land Use Control Alternative, the Targeted Soil Cover with Land Use Controls alternative includes long-term performance of perimeter patrols making it a slightly more complex monitoring plan to implement. Monitoring is not a component of the No Action alternative.

4.5 Technical practicability

Technical practicability is not a consideration for the No Action alternative as there is no remedial action. Numerous qualified vendors and contractors and sufficient local materials are available to implement the Targeted Soil Cover with Land Use Controls alternative and, to a lesser extent for materials procurement, the Full Soil Cover with Institutional Controls alternative. The perimeter patrols and discrete areas of cover of the Targeted Soil Cover with Land Use Controls alternative are marginally more reliable than the full cover of the Full Soil Cover with Institutional Controls alternative in terms of minimizing potential exposure to human receptors. The full soil cover of the Full Soil Cover with Institutional Controls alternative is marginally more reliable than the Targeted Soil Cover with Land Use Controls alternative in terms of minimizing potential exposure to ecological receptors. The Excavation and Off-site Disposal alternative would be significantly more difficult to implement primarily due to the large volume of material involved and the proximity to surface waters.

4.6 Restoration time frame

The Targeted Soil Cover with Land Use Controls alternative would achieve RAOs in less than one year from the start of construction. The Full Soil Cover with Institutional Controls alternative would achieve RAOs in approximately three years from the start of construction. The excavation and Off-site Disposal alternative would achieve RAOs after 23 years of construction. The No Action alternative would not achieve RAOs.

4.7 Reduction of toxicity, mobility and volume of contamination

The Excavation and Off-site Disposal alternative permanently reduces the toxicity, mobility, and volume of COCs at OU2 by transferring ash material off-site. This alternative significantly reduces potential risks at OU2 by transferring the potential risks off-site to be managed at a permitted facility. The Targeted Soil Cover with Land Use Controls and Full Soil Cover with Institutional Controls would not reduce toxicity, mobility, or volume of COCs; however, these alternatives would minimize risks from the potential exposure to and migration of ash material in soil. The No Action alternative would not reduce toxicity, mobility, or volume of COCs and would have no effect on potential risk.

4.8 Long-term effectiveness

The Excavation and Off-site Disposal alternative is effective in the long-term in removing ash material and the presumed source of COCs to minimize potential risk at the restored OU2. The Targeted Soil Cover with Land Use Controls and Full Soil Cover with Institutional Controls alternatives are effective in the long-term for minimizing current potential risk from ash material in soil at OU2; however, long-term monitoring, maintenance, and enforcement of components of the remedies would be required to achieve the effectiveness. The Targeted Soil Cover with Land Use Controls alternative and the Full Soil Cover with Institutional Controls alternative are comparable in long-term effectiveness in terms of minimizing potential exposure to human receptors. The No Action alternative is not effective in the long-term for addressing current potential risk from ash material at OU2.

4.9 Short-term effectiveness

The Targeted Soil Cover with Land Use Controls alternative has the smallest construction effort of the three remedial alternatives involving site disturbance and, therefore, is the most easily managed for effectiveness in the short-term. The Full Soil Cover with Institutional Controls alternative has a larger construction effort than the Targeted Soil Cover with Land Use Controls alternative but potential risk of exposure to ash material is limited to trained construction workers. The No Action alternative is not effective in the short-term for addressing current potential risk from ash material at OU2. The Excavation and Off-site Disposal alternative significantly increases potential risks to new human and ecological receptors during implementation and requires close management and proper implementation of mitigation measures. In particular, the ash material would be transported through the community increasing potential risk of traffic accidents and exposure. The Excavation and Off-site Disposal alternative does not address the existing potential risks to human health and ecological receptors until completed in 23 years.

4.10 Cost

The No Action alternative does not have an associated monetary cost for implementation. The Targeted Soil Cover with Land Use Controls alternative has the lowest estimated capital, O&M, and total present worth costs of the three remedial alternatives with associated costs. The estimated capital (total and present worth) and total present worth costs for implementation of the Full Soil Cover with Institutional Controls are approximately one order of magnitude higher than those for the Targeted Soil Cover with Land Use Controls alternative and the estimated total O&M present worth cost is approximately three times higher. The estimated capital present worth cost for the Excavation and Off-Site Disposal alternative is approximately 259 times higher than that for the Targeted Soil Cover with Land Use Controls alternative, the estimated total O&M present worth cost is approximately double, and the estimated total present worth cost is approximately 141 times higher.

Table 4-1

Summary of Comparative Analysis of Alternatives

ALTERNATIVE / CRITERIA	S-1 No Action	S-2 Targeted Soil Cover with Land Use Controls	S-3 Full Soil Cover with Institutional Controls	S-4 Excavation and Off-site Disposal
Threshold Criteria				
Protective of Public Health, Welfare, and the Environment	No	Yes	Yes	Yes
Complies with Applicable Laws and Regulations	No	Yes, easy	Yes, moderate	Yes, difficult
Balancing Criteria				
Community Acceptance	TBD	TBD	TBD	TBD
Compliance Monitoring Requirements	None	Moderate, short- and long-term	Moderate, short- and long-term	Easy, short-term
Technical Practicability	Easy	Easy	Moderate	Difficult
Restoration Time Frame (time to achieve RAOs)	NA	<1 year	3 years	23 years
Reduction of Toxicity, Mobility, and Volume of Contamination	None	Low reduction	Low reduction	High reduction
Long-term Effectiveness	None	Moderate	Moderate	High
Short-term Effectiveness	None	High	Moderate	Low
Cost	None	Low	Moderate	High

Notes:
NA – not applicable
TBD – to be determined

5.0 Preferred Alternative and Justification

Based on the screening and detailed analysis presented in this FS, alternative S-2, Targeted Soil Cover with Land Use Controls is the preferred remedial alternative for OU2. As detailed in Section 2.3.2.2, the Targeted Soil Cover with Land Use Controls alternative includes clearing discrete areas of vegetation, grading and placing soil cover over discrete areas of currently exposed ash material in soil and unstable slopes in OU2, performing perimeter patrols, maintaining 'no trespassing private property' signs, establishing a UEC to limit future land use, and long-term monitoring.

This alternative achieves the RAOs without incurring significant habitat and vegetation destruction for implementation. The approach for achieving each RAO is summarized in Table 5-1 below. Potential future additional remedial actions can be implemented easily if deemed necessary by the results of long-term monitoring, which is a component of the remedy.

Table 5-1

Approach for Achievement of RAOs Under the Preferred Alternative

RAOs	Approach for Achievement Under the Preferred Alternative S-2: Targeted Soil Cover with Land Use Controls
Minimize human cancer risks and non-cancer hazards from exposure to soil.	Limits potential exposure to ash material in soil thereby minimizing risks and hazards.
Minimize migration of constituents of concern (COCs) from OU2 to other OUs or off-site.	Minimizes potential migration of COCs by controlling exposed ash material in soil.
Reduce ecological risk (to terrestrial populations and communities) to lowest practicable levels.	Limits potential exposure to ash material in soil thereby minimizing ecological risks.
Minimize unnecessary injuries to natural resources resulting from remedial action.	Temporary adverse impacts in discrete areas associated with existing vegetation clearing.
Ensure no significant degradation of groundwater, surface water, or sediment quality beyond existing levels.	No anticipated change in current groundwater condition. Controls potential source of COCs from entering surface water or sediment via overland flow.
Ensure human cancer risk is less than 1×10^{-5}.	If the exposure frequency is reduced to 16 days per year as a result of the perimeter patrols, the estimated carcinogenic risk would be reduced to 9.4×10^{-6} for the child trespassing recreational fisherman.
Ensure human non-cancer Hazard Index (HI) is less than 1.	If the exposure frequency is reduced to 16 days per year as a result of the perimeter patrols, the estimated non-carcinogenic hazard would be reduced to 0.24 for the child trespassing recreational fisherman.

6.0 References

Delaware Department of Natural Resources and Environmental Control (DNREC), 2012. Division of Waste and Hazardous Substances, Statutory Authority: Title 7 Delaware Code, Chapter 91, 7 DE Admin. Code 1375, Final, Secretary's Order No.: 2012-WH-0024, Date of Issuance: July 10, 2012, Effective Date of the Amendment: August 11, 2012, 1375 Regulations Governing Hazardous Substance Cleanup.

DNREC, 2009. *2009 Delaware Fish Consumption Advisories*, http://www.dnrec.delaware.gov/fw/Fisheries/ Documents/DE%20Fish%20Advisory%20Chart%202009%20final.pdf.

DNREC, 2008. *Approval of Final Plan of Remedial Action for Burton Island Ash Disposal Area (Operable Units 1 & 3)*. Secretary's Order No. 2008-A-0032. Department of Natural Resources and Environmental Control, Dover, DE.

DNREC, 1999. *Remediation Standards Guidance Under the Delaware Hazardous Substance Cleanup Act*.

DNREC, 1994. *Hazardous Substance Cleanup Act Guidance Manual*, October.

Greene, R. and E. Crecelius, 2006. *Total and Inorganic Arsenic in Mid-Atlantic Marine Fish and Shellfish and Implications for Fish Advisories*. Integrated Environmental Assessment and Management, Vol. 2, No. 4 pp. 344-354.

Shaw Environmental, Inc. (Shaw), 2011. *Remedial Investigation Report, Indian River Generating Station, Operable Unit No. 2, Burton Island Old Ash Landfill, Millsboro, Delaware, Site Number DE-1399*. August 2011.

Shaw, 2010a. *Remedial Investigation Work Plan, Indian River Generating Station, Operable Unit No. 2, Burton Island Old Ash Landfill, Millsboro, Delaware, Site Number DE-1399*. April 2010.

Shaw, 2010b. *Remedial Investigation Work Plan Addendum, Indian River Generating Station, Operable Unit No. 2, Burton Island Old Ash Landfill, Millsboro, Delaware, Site Number DE-1399*. April 2010.

Shaw, 2008. *Facility Evaluation Report, Indian River Generating Station, Burton Island Old Ash Landfill, Millsboro, Delaware, Site Number DE-1399*. March 2008.

U.S. Environmental Protection Agency (USEPA), 2006. *In Situ Treatment Technologies for Contaminated Soil*. Engineering Forum Issue Paper, Office of Solid Waste and Emergency Response, Washington, DC. USEPA-542-F-06-013. November 2006.

USEPA, 2001. *A Citizen's Guide to Phytoremediation*. Office of Solid Waste and Emergency Response, Washington, DC. USEPA-542-F-01-002. April 2001.

USEPA, 2000. *Bioaccumulation Testing and Interpretation for the Purpose of Sediment Quality Assessment, Status and Needs*. Office of Water and Office of Solid Waste, Washington, DC. USEPA-823-R-00-001.

USEPA, 1997. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*. Office of Solid Waste and Emergency Response, Washington, DC. USEPA 540-R-97-006.

USEPA, 1994. *Feasibility Study Analysis for CERCLA Municipal Landfill Sites*. Office of Solid Waste and Emergency Response, Washington, DC. USEPA 540-R-94-081. August 1994.

USEPA, 1988a. *Technology Screening Guide for Treatment of CERCLA Soils and Sludges*. Office of Solid Waste and Emergency Response, Washington, DC. USEPA 540-2-88-004. September 1988.

USEPA, 1988b. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*. Office of Solid Waste and Emergency Response, Washington, DC. USEPA 540-G-89-004. October 1988.

FIGURES

APPENDIX A

APPENDIX B

APPENDIX C

APPENDIX D

This page intentionally left blank.

APPENDIX E

This page intentionally left blank.